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SATURN I ELECTRICAL POWER AND SYSTEMS INTEGRATION
SA-5 THROUGH SA-7

By

A. A. Conway and H. K. Bennett

NASA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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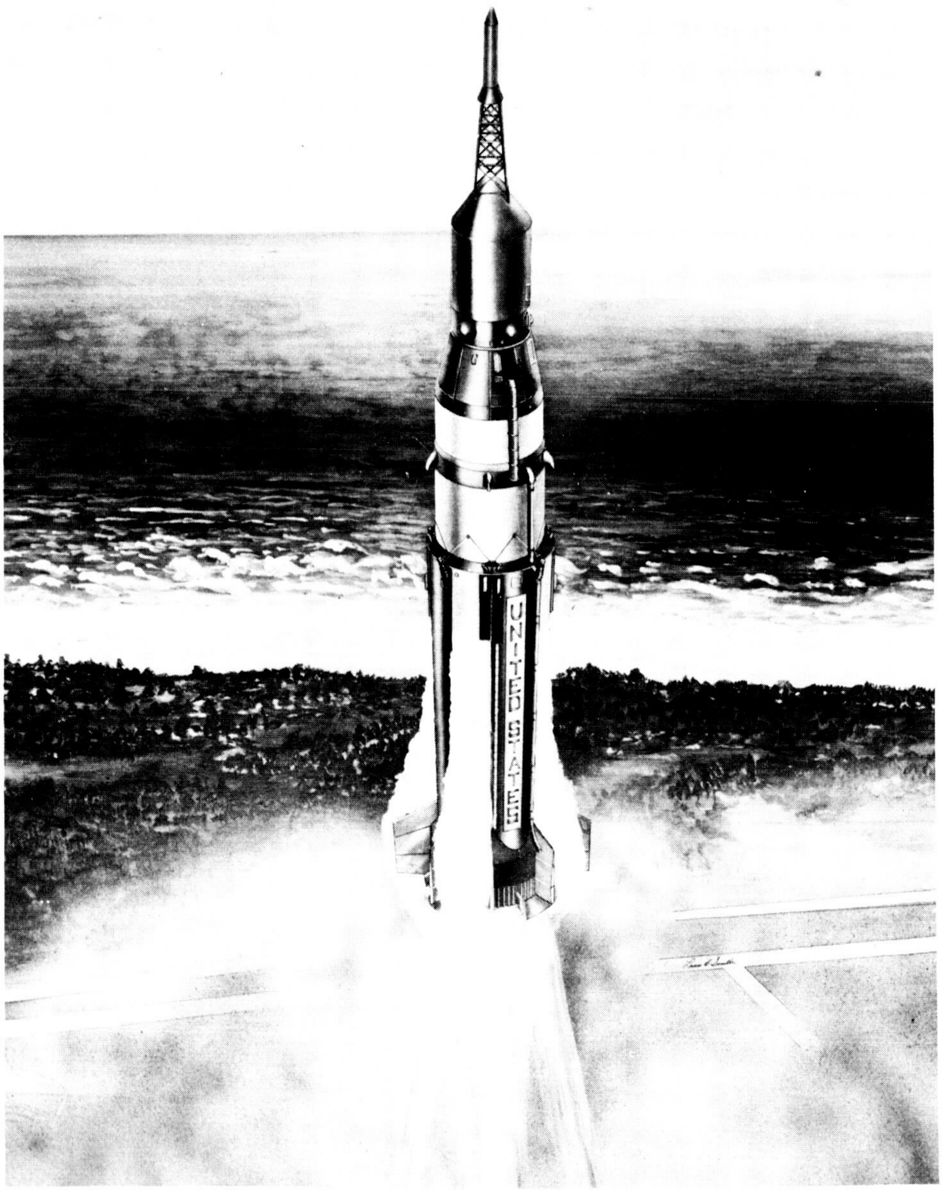
ELECTRICAL SYSTEMS INTEGRATION BRANCH
ASTRIONICS DIVISION



SATURN
I

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ABSTRACT

The Saturn SA-5 through SA-7 electrical system networks, hardware, and the integration scheme used to bring vehicle subsystems together as a functional electrical unit are presented. The various subsystems to which electrical power is supplied are pointed out; these subsystems are described only as necessary to define the systems that require electrical integration. A simplified electrical interconnection diagram of the system is included to show the integration scheme. The integration components are distributors, flight sequencer, flight sequencer slave, exploding bridgewire, switch assemblies, timers, and plug "J" boxes. The power components are batteries, 56-volt power supplies, 2400-volt power supplies, control voltage power supplies, master measuring voltage supplies, and measuring voltage supply modules. Descriptions and illustrations of these components are included. Simplified circuit examples and descriptions of the circuits through the various distributors, switch assemblies, and plug "J" boxes are given.

author

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SUMMARY

The Saturn SA-5 through SA-7 electrical system networks, hardware, and the integration scheme used to bring vehicle subsystems together as a functional electrical unit are presented. The various subsystems to which electrical power is supplied are pointed out; these subsystems are described only as necessary to define the systems that require electrical integration. A simplified electrical interconnection diagram of the system is included to show the integration scheme. The integration components are distributors, flight sequencer, flight sequencer slave, exploding bridgewire, switch assemblies, timers, and plug "J" boxes. The power components are batteries, 56-volt power supplies, 2400-volt power supplies, control voltage power supplies, master measuring voltage supplies, and measuring voltage supply modules. Descriptions and illustrations of these components are included. Simplified circuit examples and descriptions of the circuits through the various distributors, switch assemblies, and plug "J" boxes are given.

SECTION I. INTRODUCTION

A. SATURN SA-5 THROUGH SA-7 (FIG. 1)

The SA-5 through SA-7 vehicles of the Saturn I configuration are steps in continuation of the R&D program to design and develop launch vehicles needed for the NASA planned lunar landings and space operations. SA-5 is the first vehicle to carry an active S-IV second stage and an Instrument Unit. The Instrument Unit (IU), mounted above the S-IV stage as an additional vehicle segment, houses much of the astrionics equipment to deliver electrical power and to guide, control, and transmit signals on vehicle status during countdown and flight. In addition to the S-IV stage and IU, a payload consisting of a Jupiter-type nose cone, aft unit, and an adapter will be flown on the SA-5 vehicle. A boilerplate Apollo payload will be carried atop the SA-6 and SA-7 vehicles. The boilerplate Apollo will simulate weight and aerodynamic design of

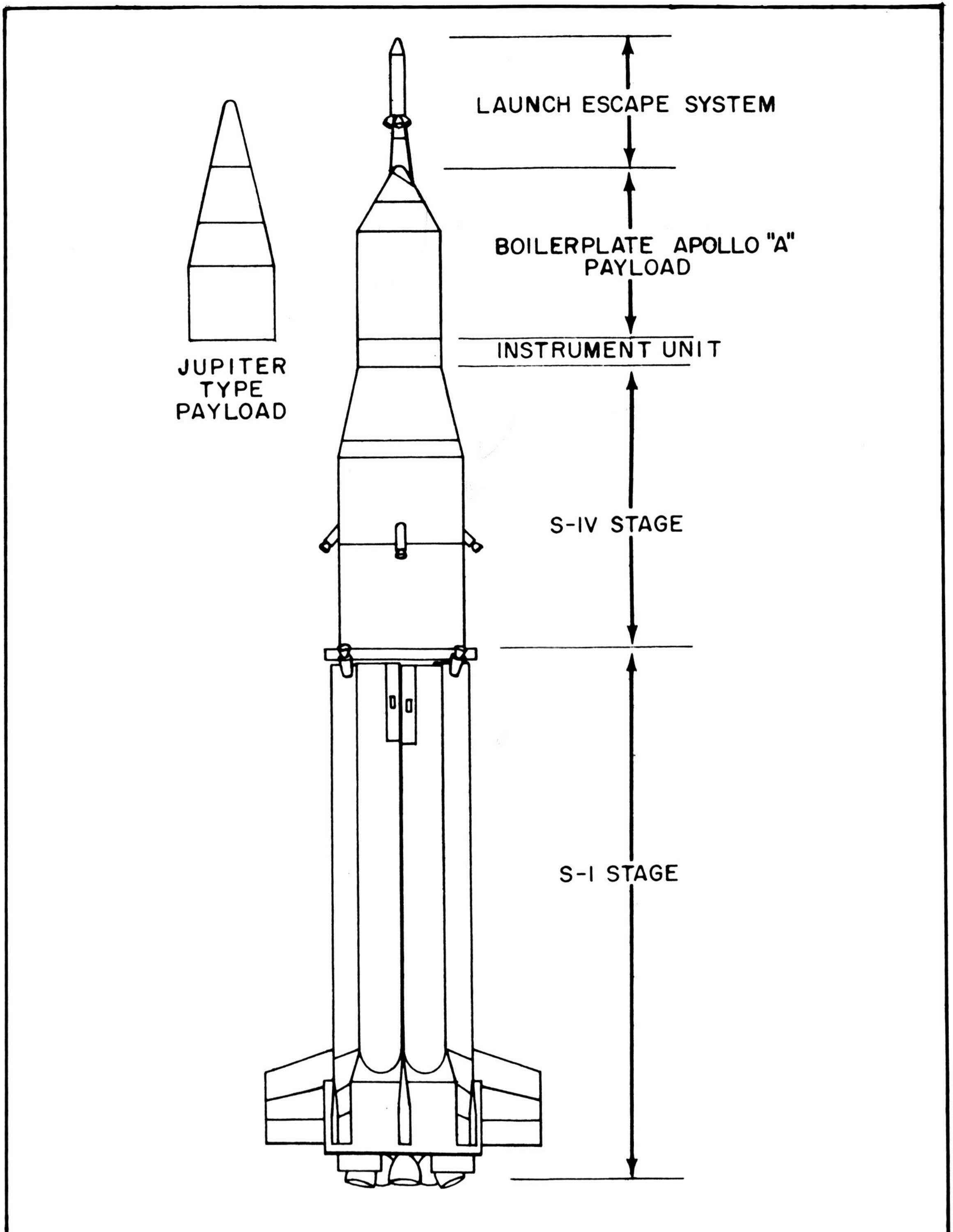


FIGURE 1. SATURN SA-5 THROUGH SA-7.

the Apollo "A" spacecraft to be orbited by later vehicles. Low earth orbits will be attempted with the boilerplate Apollo configuration. The major objectives of the block II test flights are as follows:

1. To flight test the two-stage Saturn I launch vehicle, consisting of stages S-I and S-IV.

2. To demonstrate the compatibility of the boilerplate Apollo payload and the two-stage Saturn I launch vehicle.

3. To measure the payload and launch vehicle environments.

4. To validate systems and subsystems for Apollo "A" spacecraft for manned flights.

B. VEHICLE DESCRIPTION

The S-I stage of Saturn SA-5 through SA-7 vehicles will be of the same basic configuration as that of block I Saturn vehicles. The S-I stage structure consists basically of the thrust structure assembly, fins, tail assembly shroud, propellant containers, and spider beam assembly.

Four stabilizing fins are attached to the S-I stage thrust structure at 90 degree intervals around the circumference of the tail assembly. Four smaller fins, called stubs, are attached to the S-I stage between the larger fins. The purpose of the large fins and stub fins is to increase the aerodynamic stability of the vehicle. The fins also provide hold-down and support points for the vehicle on the launch pad.

The S-I stage has nine cylindrical propellant containers with hemispherical end bulkheads. Four of the smaller containers are for RP-1 (kerosene) fuel and the other four are for liquid oxygen. The eight smaller containers are mounted in a circular pattern around the center liquid oxygen container.

The S-I stage is propelled by eight H-1 engines. Four solid propellant retrorockets are mounted at the top of the S-I stage. Their function is to slow down the S-I stage so that the S-IV stage will move away from it after separation. These rockets are ignited approximately 100 ms after the separation signal fires the explosive nuts to separate the S-I from the S-IV stage. The burning time of the retrorockets is 2.2 seconds.

Saturn SA-5 through SA-7 launch vehicles incorporate live S-IV stages instead of the dummy units as used in block I Saturn vehicles. The S-IV stage consists of four major assemblies: the forward interstage, the propellant container assembly, the aft interstage, and the engine thrust structure.

Six RL10A-3 engines use liquid hydrogen and oxygen in a simple, low-pressurized propellant feed system. To control flight direction, the engines gimbal through four degrees in response to signals from the Instrument Unit located forward of the stage.

The aft interstage adapts the stage to the S-I booster. The S-I/S-IV interstage remains with the S-I stage upon separation of the two stages. This separation sequence starts with a propellant depletion signal from the S-I stage. After separation and approximately two seconds free-coast, the engines of the S-IV stage start and the flight continues. Nominal burning time is 467 seconds. Each of the two tanks contains a capacitance probe that produces an electrical signal in proportion to the mass of propellant in the tank. The signals are combined in a control system to maintain the proper ratio of oxygen and hydrogen.

The forward interstage is similar to the aft interstage in construction. It adapts the S-IV stage to the Instrument Unit.

The SA-5 through SA-7 Instrument Unit has four tubes in which much of the electrical equipment is mounted. The instrument tubes are arbitrarily assigned numbers I, II, III, and IV. Other instrumentation contained in the Instrument Unit is mounted in the center cylinder. The location of the electrical systems integration components and the power components in the Instrument Unit is shown in Section III.

C. SATURN BLOCK II ELECTRICAL SYSTEM

Every subsystem depends upon the electrical system for Saturn block II to insure proper operation; therefore, mission success depends upon how well the electrical system functions. The electrical system provides all necessary power, switching, and control functions to the various subsystems such as propulsion, control, guidance, etc. Initially, the subsystem components were designed as independent units. After the subsystem functional requirements were confirmed, packaging and location of the components were accomplished. An important rule followed in the design of the Saturn was to limit the components only to those needed for proper flight of the vehicle. By using this approach for the design of the various subsystems, the overall system can be expressed by a simplified electrical interconnection diagram (FIG. 2). The common needs and interconnection from one system to another brought about the development of a central distribution point where all of these functions are controlled. The distribution center used in this vehicle insures clean design of the complete system and provides the flexibility needed to incorporate design changes.

After the principal vehicle functions were established, the power and voltage requirements were computed for each of the various loads. Most voltages used in the vehicle system are 28 V d.c. and 115 V 400 Hz.

Both the S-I stage and the Instrument Unit have two independent 28-volt bus systems. Normally, constant loads are supplied from one bus and variable loads are supplied from the other bus.

To maintain flexibility of electrical system capability, the vehicle electrical distribution centers are divided into emergency detection, power, control, measuring, main, and propulsion distributors. The S-I stage contains one main, one power, one propulsion, and five measuring distributors. The Instrument Unit contains one power, one control, one measuring, and one emergency detection distributor. The two power distributors contain all heavy-load d.c. switching, such as main power switchover from the ground to the vehicle. The a.c. power is also routed through these distributors.

As stated earlier, the overall electrical system layout is started with a cable interconnection diagram, which identifies each cable harness. Since the interconnecting of all electrically-operated equipment is centrally controlled by the distributor design, electrical systems hardware can be prefabricated and inspected prior to delivery to vehicle for installation. During the vehicle assembly operations, it is only necessary to secure the components in position and to place the cable harness properly. The interconnection diagrams show the cable distribution from component to component. Where signal transmission occurs without switching, cables are provided to connect such components directly. In other cases, the components are interconnected through the electrical network by the distributors. Within the distributors, the operating voltages are picked up, event signals are provided, and output signals are dispatched as required.

The control of inflight sequential events after liftoff is derived from the program device on SA-5 and SA-6. On SA-7, the control of sequential events will be derived from the guidance computer. One channel of the program device delivers the pulses to the flight sequencer. Operation of the program device and flight sequencer combination system is described in section III.

Another important function of the electrical system is to provide checkout capability of all components and subsystems without interrupting vehicle circuitry. Test and countdown sequences were designed into the complete electrical system; to accomplish this, a close liaison was maintained with subsystem design groups at all times. The electrical system is so designed and integrated that a failure of a major component or circuit will interrupt the countdown sequence.

SECTION II. VEHICLE SUBSYSTEMS

The subsystems briefly described in this section employ electrical components to operate and monitor the various vehicle functions. The monitoring equipment determines whether the subsystems are operating as

designed. These components and equipment are integrated into the overall electrical network so the vehicle may accomplish its planned mission.

A. ELECTRICAL POWER

The electrical power system of Saturn SA-5 through SA-7 consists of 28-volt batteries, 5 types of power supplies, and 450 VA static inverters. One pair of the batteries is located in unit 12 of the S-I stage and the other pair is located in the Instrument Unit. Each battery supplies an independent bus.

Vehicle battery power is switched on at power transfer by contactors in the power distributor. Power transfer is the switching of d.c. power from ground generators to vehicle batteries.

A 60 V d.c. power supply, located in the Instrument Unit, provides a highly filtered and precisely regulated reference signal to the control system command and feedback potentiometers for guidance and control of the vehicle.

Eight measuring voltage supply modules, located in the S-I stage, supply precisely regulated 5 V d.c. reference voltage to the engine systems to be used with telemetry.

Two master measuring voltage supplies are located in the vehicle. One is located in unit 12 of the S-I stage and the other is located in the Instrument Unit. These voltage supplies are used for measuring references and for supplying precisely regulated, isolated 5 V d.c. reference voltages to the various measuring devices.

The 56 V d.c. power supply provides a regulated voltage output from no load to full load. It is used in the Instrument Unit to provide power for the torque amplifiers of the ST-124 stabilized platform.

The 2400 V power supply, located in the S-IV interstage, is a static converter used to furnish power to the strobe lights. The output of this power supply is a ramp function of 2400 V peak at a continuous current of 150 mA.

Another type of electrical power equipment, although not furnished by the Electrical Systems Integration Branch, is the 450 VA static inverter that has an input of 28 V d.c. and an output of 3 phase 115 V 400 Hz. Four inverters are used on SA-5 and SA-6 (3 in the Instrument Unit and 1 in the S-I stage), while only three are used on SA-7 (2 in the Instrument Unit and 1 in the S-I stage).

B. ENGINE START AND CUTOFF

1. Starting Sequence (FIG. 3)

The initial start signal activates the solid propellants within the turbine spinner, and high pressure burning gases are forced into the gas turbine. Driven by the gases, the gas turbine accelerates and drives the fuel and oxidizer turbopump through the turbopump gearbox. At this point, the turbopump is working against closed propellant valves. Fuel is forced through a fuel feeder line connected to the main fuel line above the main fuel valve. This fuel discharge line carries the pressurized fuel to the main oxidizer valve, the lube additive blender, and the squib-operated conax valve. The fuel additive blender supplies an Oronite lubricant during flight. The conax valve, normally closed, does not function during starting, but begins to open when the fuel pressure reaches approximately 14 kg/cm^2. A sequence valve, which is mechanically linked to the main oxidizer valve, opens when the oxidizer valve has partially opened, allowing the pressurized fuel to flow to the hypergolic igniter. The burst-diaphragms of the hypergolic igniter rupture at approximately 21 kg/cm^2, allowing the hypergolic mixture and igniter fuel to flow toward the thrust chamber. On the downstream side of the hypergolic igniter, the fuel pressure begins to overcome the spring closing pressure of the main fuel valve (providing the ignition monitor valve in the thrust chamber indicates that primary ignition has taken place). From the main propellant lines, fuel and oxidizer flow to the gas generator with a slight oxidizer lead to start bootstrap operation. The liquid oxygen and fuel mixture supplied by the bootstrap lines are ignited by contact with hot gases from the gas generator. As combustion becomes stable in the gas generator, main stage operation is sustained.

2. Cutoff Sequence (FIG. 4)

Engine cutoff is initiated by means of a squib-actuated conax valve. Upon receipt of an electrical signal, an explosive charge within this valve bursts a metal diaphragm, allowing fuel to flow under pressure to the closing side of the main oxidizer valve. Spring pressure closes the main oxidizer valve, cutting off liquid oxygen flow to the thrust chamber and to the gas generator. Turbopump speed and pressure begin to decay. When fuel pressure reaches approximately 14 kg/cm^2, spring closing pressure in the main valve overcomes fuel pressure and the valve closes. Thus, the fuel to the engine is cut off. Engine shutdown is completed approximately one second after the initial cutoff signal.

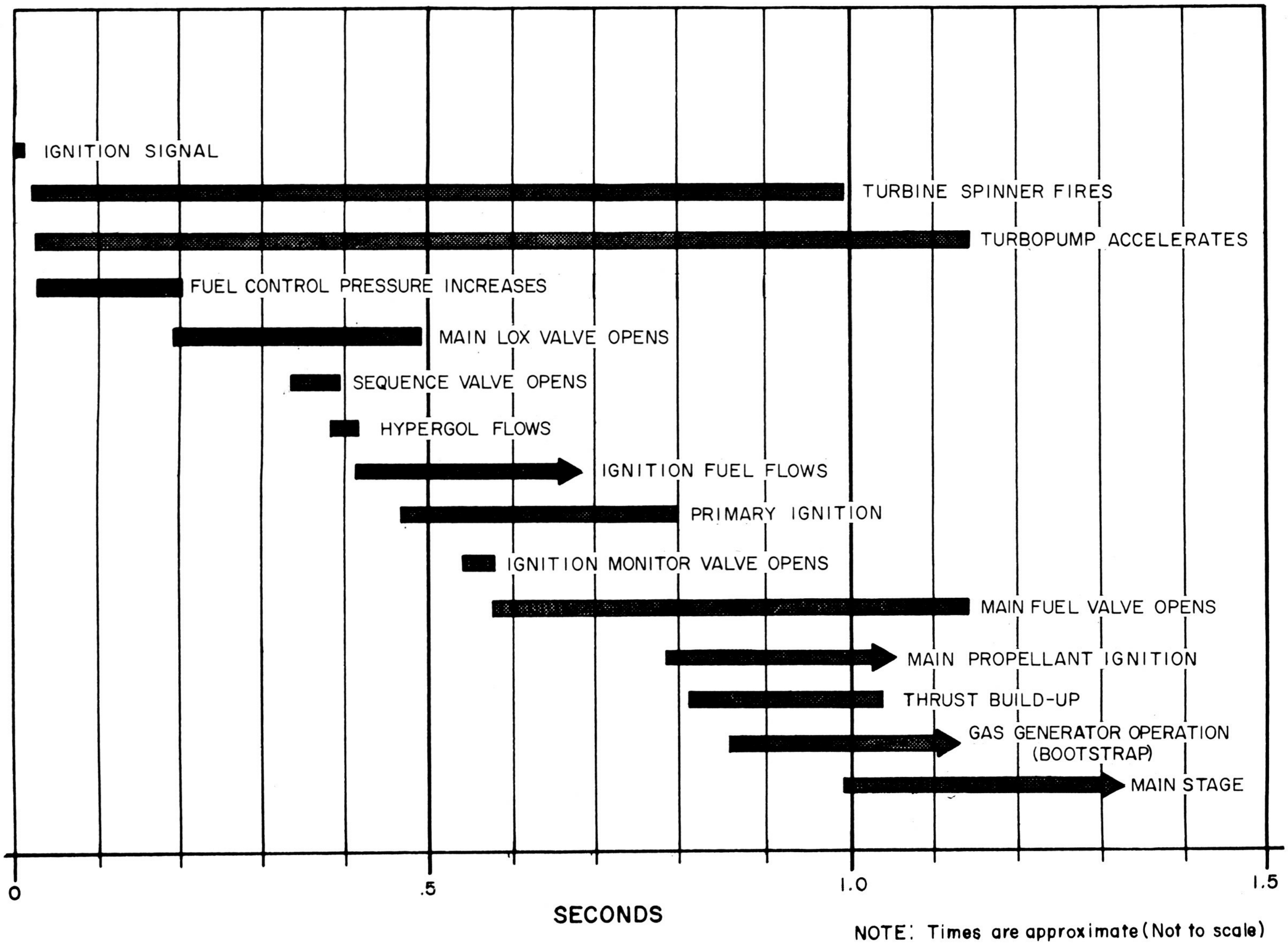
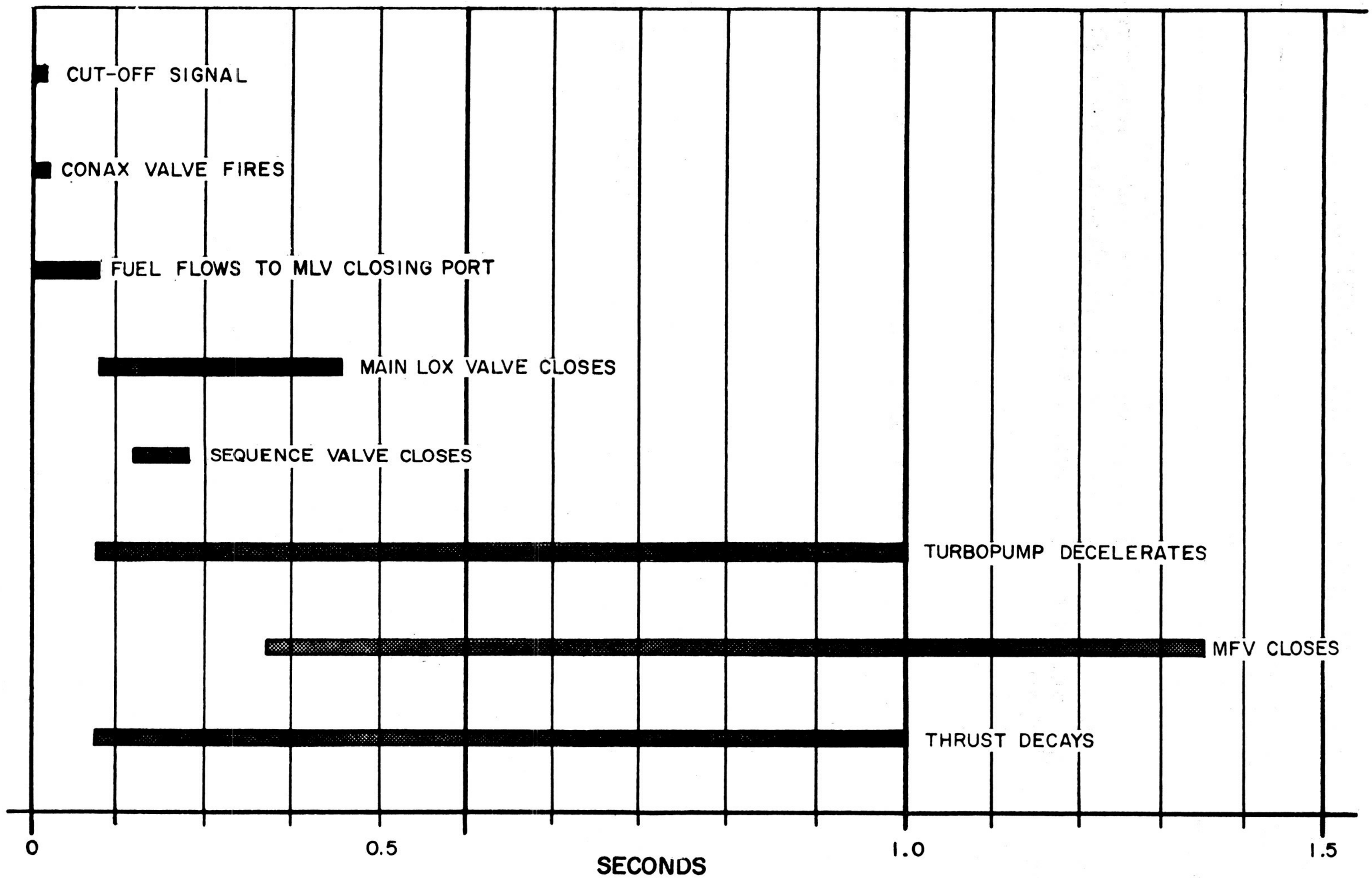


FIGURE 3. ENGINE START SEQUENCE.



NOTE: Times are approximate.(Not to scale.)

FIGURE 4. ENGINE CUTOFF SEQUENCE.

TABLE 1. PRELIMINARY SA-5 S-I PROGRAM

Step	Flight Time From Liftoff	Function
1	LO+2	Spare
2	LO+10	Energize engine-out time relay
3	LO+21	Spare
4	LO+30	Spare
5	LO+39	Close fuel press valve No. 3; start recorder
6	LO+54	Close fuel press valve No. 2; start camera lens purge
7	LO+70	Close fuel press valve No. 1; energize LOX-SOX high pressure valves Nos. 1 and 2
8	LO+85	Spare
9	LO+102	S-IV telemetry calibrate command
10	LO+113	LH_2 prestart; power to 6 cameras
11	LO+125	Power to charge port vent EBW
12	LO+132	Enable propellant level sensors
13	LO+140.0	Inboard cutoff; open LOX-SOX purge valves Nos. 2, 3, 5, and 6
14	LO+142	Spare
15	LO+142.8	Open LOX-SOX purge valve No. 4
16	LO+143.4	Spare
17	LO+143.9	Open LOX-SOX purge valves Nos. 1 and 7
18	LO+146	Outboard engine cutoff
19	LO+146.2	Spare
20	LO+146.6	Separation - signal to separation EBW firing unit and retrorocket EBW firing units. Start 25 second delay timer for camera ejection and tape recorder playback

TABLE 2. PRELIMINARY SA-5 IU PROGRAM

Step	Flight Time From Liftoff	Function
1	LO+5	Extended roll on
2	LO+20	Extended roll off
3	LO+30	Switch point control computer
4	LO+60	Switch point control computer
5	LO+90	Switch point control computer
6	LO+134.4	Stop program device
7	LO+146.289	Fire ullage rockets
8	LO+146.4	Switch control system to S-IV stage; S-I/S-IV stage separation
9	LO+147.8	Activate He heaters LOX valve
10	LO+148.1	S-IV engine start
11	LO+151.0	Enable S-IV engine-out
12	LO+152.0	Spare
13	LO+153.0	Enable S-IV propellant utilization
14	LO+166.4	Jettison ullage rockets
15	LO+450.4	Tape recorder record
16	LO+510	Switch point control computer
17	LO+598.4	Arm S-IV engine cutoff
18	LO+603.4	S-IV engine cutoff
19	LO+632.4	Tape recorder stop
20	LO+635.4	S-IV telemeter calibration and tape recorder playback

C. FLIGHT SEQUENCING

1. Program Device

The program device, the source of all inflight sequencing, provides accurately-timed pulses used to initiate and program various guidance, control, and sequenced functions. It is a precise 6-channel magnetic tape recorder, of which 3 channels are used for programing the Saturn vehicle. One channel supplies the pulses for the S-I sequencing, another supplies the pulses for the Instrument Unit sequencing, and the third is used for activating the telemeter calibration commutator. The program device tape starts operating from zero at liftoff; the time of actual start-to-stop operation is based on vehicle liftoff. A few seconds before fuel depletion, the program device is stopped and then restarted at fuel depletion. This means that all times related to program device operation after this point are based on fuel depletion of the S-I stage. At 1.9 seconds after fuel depletion signal, the four inboard engines are cut off; then 6 seconds later, the outboard engines are cut off. The program device will be omitted after SA-6 and its functions will be taken over by the control computer.

2. Flight Sequencer

The flight sequencer is a series of relays designed to receive and respond to pulses from the program device. Each time the program device sends a pulse to the flight sequencer, a relay in the series is operated, and the circuitry for vehicle system sequencing is completed. The step functions of the flight sequencer and slave for both the S-I stage and the Instrument Unit are listed in Tables 1 and 2 (Preliminary S-I Program and Preliminary Instrument Unit Program).

D. GUIDANCE AND CONTROL

The heart of the control system is the control computer and its actuating equipment (FIG. 5).

The stabilized platform and its auxiliary sensing equipment serve as the basic reference for signals of the control system. The control system senses and stabilizes the vehicle in flight through the null-seeking devices that continuously compare the actual flight information with the programed flight data. The signals derived from the stabilized platform are channeled through the vehicle circuitry to the control computer. The control computer translates these signals into control signals and routes them to the electro-hydraulic actuators which gimbal the four outboard engines accordingly.

The power for operating the control system components is furnished through the vehicle network system. The integration and interconnection of the vehicle control system with the ground support equipment are accomplished through the electrical integration system.

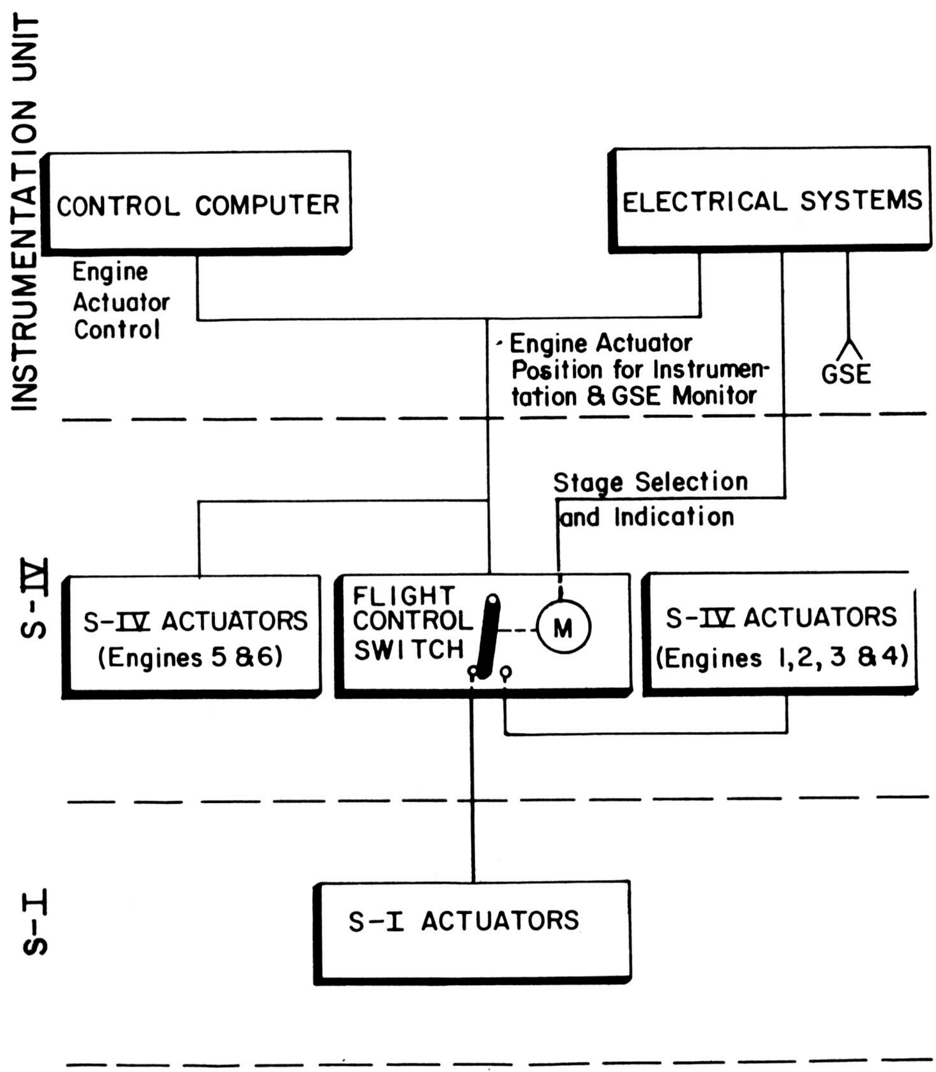


FIGURE 5. CONTROL SYSTEM BLOCK DIAGRAM.

E. PRESSURIZATION, HEATING, AND COOLING

1. Pressurization

a. Fuel Pressurization. Nitrogen gas (GN_2) pressure is supplied from the pressure spheres to the fuel tanks through the air manifold. The GN_2 pressure is controlled by three fuel tank pressurization valves located in the manifold system. These valves are electrically actuated by a pressure switch which is also located in the manifold system. The three pressurization valves are sequenced during powered flight by signals from the flight sequencer to the pressure switch, which cuts the pressurization valves in or out of the pressure system. The valves are cut in or out to regulate the pressurization rate required to maintain the desired pressure within the tanks. Prior to firing command, the fuel tanks are initially pressurized by a signal from the ground. The desired pressure is maintained throughout powered flight by the action of the pressure switch which activates the valves, as required, in a three-two-one-zero sequence. As the fuel is consumed, the switch senses a drop in fuel tank pressure and signals the valves to open as required. When the pressure increases, the pressure switch will signal the pressurization valves to close as the pressures reach the required value.

b. Liquid Oxygen Pressurization. The liquid oxygen (LOX) tanks are initially pressurized from a ground pressure supply. When the engines are running, the LOX is changed to gaseous oxygen (GOX) by the LOX passing through the heat exchanger. The GOX is piped from the heat exchanger to the LOX tanks for maintaining the desired pressure within the tanks. Pressure in the LOX tanks is controlled by a LOX relief vent valve which is mechanically opened at a preset pressure, thus holding the pressure in the LOX tanks constant. The LOX tanks may be electrically vented from the blockhouse at any time.

2. Heating

a. Air Bearing Air Heaters. The air supply to the air bearing gyros requires heat that is supplied by heaters located in the platform air supply lines. The heaters are energized by vehicle circuitry when the gyros are started. Thermostats located in the air lines sense the air temperature and turn the heaters off at the desired temperature. The heaters are cycled ON and OFF by these thermostats to keep the air supply to the air bearings at a constant temperature.

b. Angle-Of-Attack Meter Heaters (SA-5 Only). The four angle-of-attack meters (alpha probes) used in the control system of the vehicle contain heating elements to prevent the probes from icing during flight. Upon ground command, the alpha probes are extended and the heaters are energized. The heaters have no thermostats to prevent overheating; therefore, they are turned off at a preset time, through the flight sequencer, by vehicle circuitry.

3. Cooling

The S-I stage employs a cooling system to furnish controlled cooling for the two instrument containers that occupy the upper parts of fuel tanks F-1 and F-2. Before flight, cooled air from a ground unit is admitted into a manifold and then ducted into the instrument containers. The air is then circulated and is returned to the ground unit through another manifold. This cools the instrument containers to a temperature sufficiently low to insure an acceptable temperature range throughout the powered flight of the first stage. Before liftoff, the ground unit is disconnected and the containers are sealed off. Since the instrument canisters require venting throughout flight, because of the increase of air temperature within the canisters, a fixed orifice is installed to provide venting.

The Instrument Unit is cooled or heated as required by a ground unit during preparation for flight and until approximately 150 seconds before liftoff. A thermal probe, which is energized when the ground air conditioning equipment is started, senses temperature of the pre-cooled air being vented into the interstage compartment. This thermal probe provides control of the ground air conditioning for regulation of the pre-cooled air at the inlet to the Instrument Unit.

Approximately 150 seconds before liftoff, the ground cooling unit ceases to function and the inflight cooling system begins to operate. The inflight cooling is accomplished by gaseous nitrogen, which enters the cooled air stream and circulates throughout the Instrument Unit. A pressure switch and solenoid valve relieve excessive pressure caused by the GN_2 by bleeding the cooled air into the interstage compartment. From the interstage adjacent to the Instrument Unit (S-IV forward interstage), the cooling air is vented to the atmosphere through four orifices.

F. TELEMETER MEASURING

Being developmental vehicles, the Saturn SA-5, SA-6, and SA-7 are heavily instrumented. Approximately 1200 measurements are to be made and telemetered back to ground stations during flight. The S-I stage has 6 telemetry links that transmit data from more than 700 measurements. About 340 measurements in the S-IV stage are transmitted back to ground stations. The Instrument Unit contains telemetry links that accommodate about 200 measurements. The signals from these telemeter units are gathered from all areas of the vehicle and routed to the proper telemetry channel by the vehicle measuring circuitry.

G. TRACKING AND RANGE SAFETY

1. Tracking

The on-board units of the Saturn tracking equipment consists of UDOP (UHF doppler velocity and position), C-band radar beacon AN/DPN-55,

Azusa transponder, and Mistram (missile trajectory measurement system). This tracking equipment is powered and operated through vehicle circuitry.

a. UDOP. This system is one of the most accurate systems presently available for tracking ballistic vehicles. The vehicle-borne transponder and the fixed station transmitter and receivers describe an ellipsoid. The fixed station transmitter and receivers are at the foci, and the vehicle-borne transponder is a point on the ellipsoid surface. The distances from three stations are combined geometrically to give the position of the vehicle in space. The AN/DRN-11 transponder and CM-2670/DRN amplifier are located in the Instrument Unit.

b. C-Band Radar Beacon AN/DPN-55. The AN/DPN-55 is a compact high-power tracking aid for use in vehicles to extend the tracking range of the precision tracking AN/FPS-16 C-band radar ground station. This radar provides highly accurate trajectory data for evaluating performance and for maintaining range safety. The vehicle-borne AN/DPN-55 functions as a transponder in response to pulse interrogations from the ground station.

c. Azusa Transponder. The Azusa system provides a means for obtaining real-time (instantaneous) position and velocity information. This is an automatic, high-precision, electronic trajectory-measuring system consisting of a ground station and a vehicle-borne transponder. The system determines vehicle position by measuring slant range and direction from the ground station to the vehicle transponder.

d. Mistram. This system determines the position and velocity of a vehicle by use of interferometer radar measurements and triangulation techniques. The system measures position and velocity vectors in real time and records the data on tape for post-flight analysis. The Mistram system is comprised of a central X-band ground station, four remote ground stations, and a vehicle-borne transponder.

2. Range Safety

Range safety is a necessity to prevent injury and loss of life. The range safety officer, stationed in the central blockhouse, has complete control over the vehicle and can destroy it the instant a hazardous condition exists. If a vehicle presents a hazardous condition during flight, the safety officer will destroy it through a UHF command control and destruct system. This is a dual-channel system to provide a 100 percent backup. This system is composed of two AN/DRW-13 command receivers and the FRW-2 ground transmitter. The destruct and other vehicle commands are transmitted by frequency-modulating the dual FRW-2 command transmitter (located at the launch site) with selected combinations of audio tones. This frequency-modulated carrier is received and demodulated by each of the command receivers. The recovered audio-tones are then applied to the decoder where they are separated according to frequency to energize the proper combination of relays for execution of the desired command. The range safety antennas are located on the S-I and S-IV stages.

SECTION III. ELECTRICAL POWER AND INTEGRATION COMPONENTS

The components described in this section are the major units in the S-I stage and the Instrument Unit used to integrate the vehicle electrical systems into a functional network (FIGS. 6 through 10). The components provide, switch, distribute, and sequence the electrical energy needed to start, stop, control, and monitor the vehicle from launch to the completion of its mission. A physical and electrical description is given for at least one of each type of component. When there is more than one of the same units used in the vehicle, e.g., measuring distributor, a description of one unit is given.

A. BATTERIES - 28 VOLT

1. Type 4069 Battery (FIG. 11)

Two type 4069-3 zinc-silver oxide 28-volt batteries are located in unit 12 of the S-I stage. These batteries supply power for operating the S-I stage electrical components. There is also one type 4069-3 battery located in the Instrument Unit to supply one-half the power requirements for that unit. The remaining power requirements are furnished by a type 4070 battery.

The three type 4069-3 batteries are identical and each unit weighs approximately 34 kg. Each battery is housed in a cast magnesium case 54.6 cm by 20.8 cm by 22.6 cm, including the connectors, pressure vent, and other hardware. The two connectors on each battery are designed to permit voltage adjustment without disturbing internal cell connections. The wiring diagram (FIG. 12) depicts the cable tie points to the cells and connectors. The connectors provide a means to vary the voltage taps by choosing either 20, 21, or 22 cells. This is accomplished by connecting the desired "blind plug" to battery connector MS-3102-36-5S. The output voltage can be adjusted, depending on load requirements, to the 28-volt range by the cell selecting tap.

The nominal voltage of each cell is 1.5 volts and the nominal capacity of the battery is 2650 ampere-minutes at a 10 minute discharge rate. The cells are assembled in a dry-charge state and are prepared for use by activating with a 30 percent solution of potassium hydroxide in water. Battery activation is accomplished manually prior to installation. Activation is simplified and accurately controlled by a detailed, self-checking procedure and by the design of the activation assembly employed.

After activation, the battery is briefly load-tested to assure proper condition and performance of each cell. It may be used almost immediately thereafter without charging or soaking. Because of the primary one-shot characteristics, the battery specifications have conservatively limited the activated standby time to 72 hours at 48.8° C.

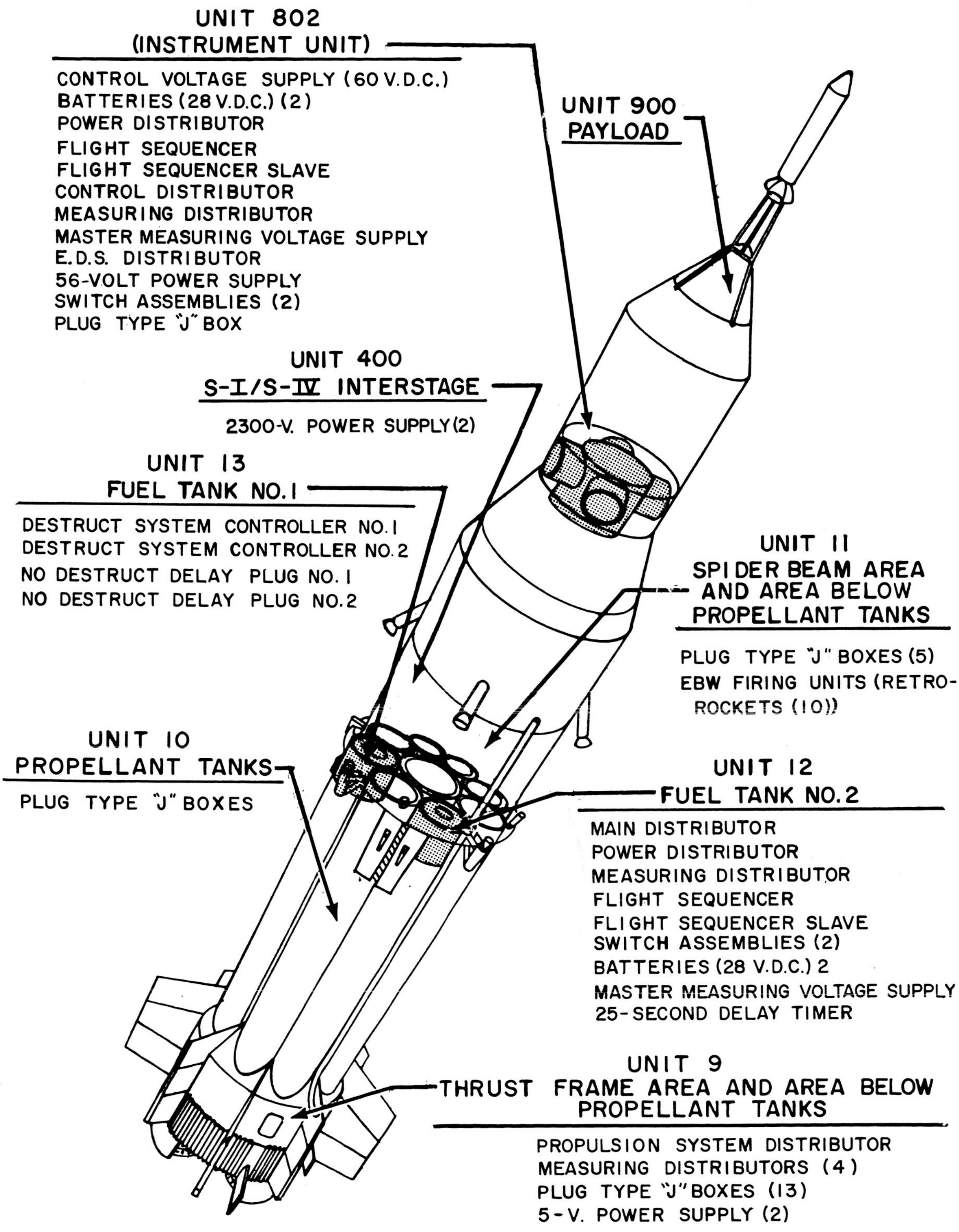


FIGURE 6. SATURN SA-5 THROUGH SA-7 ELECTRICAL SYSTEM COMPONENTS.

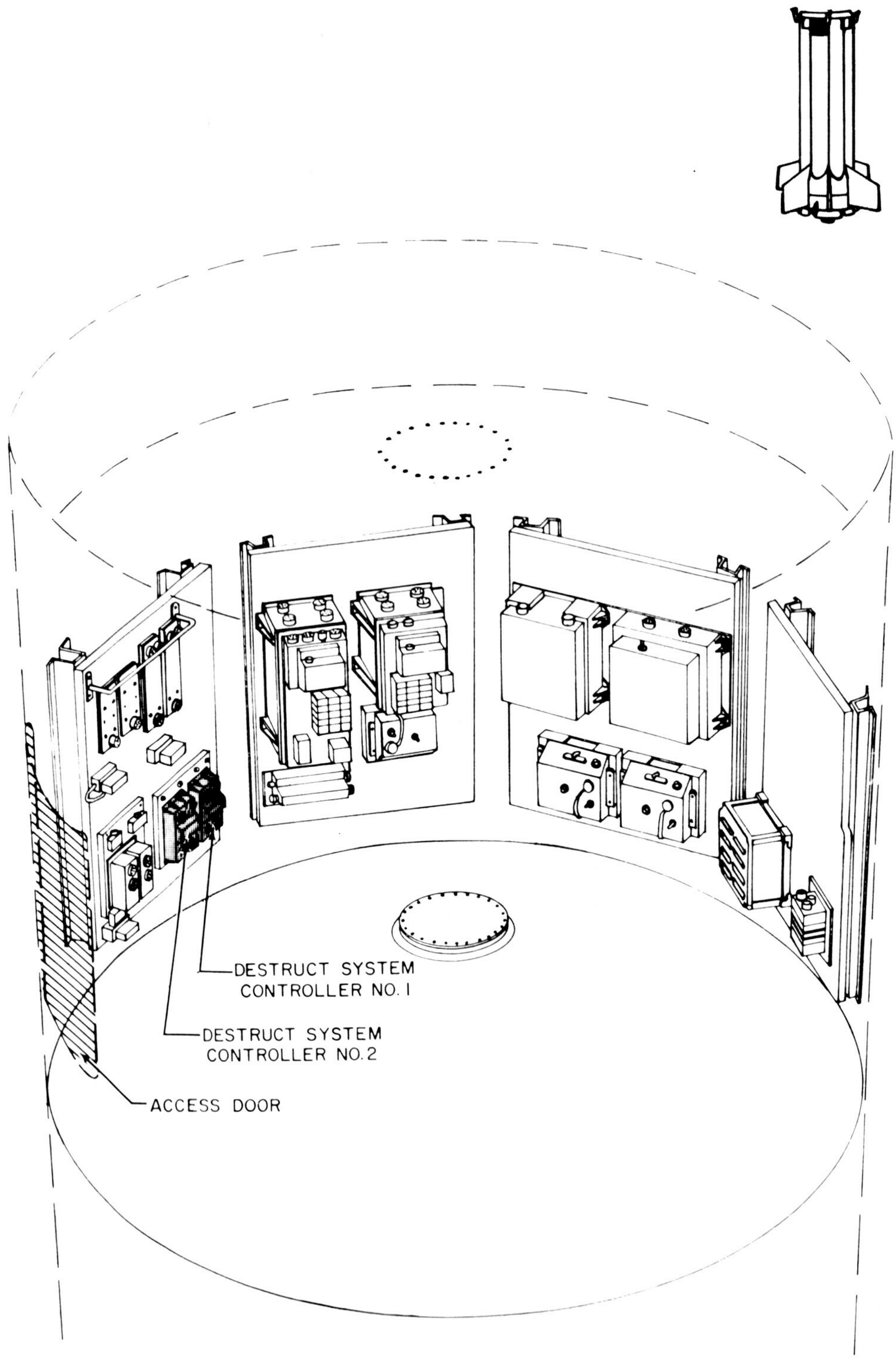
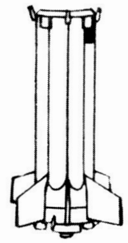


FIGURE 7. S-I STAGE INSTRUMENT COMPARTMENT ABOVE FUEL TANK NO. 1.



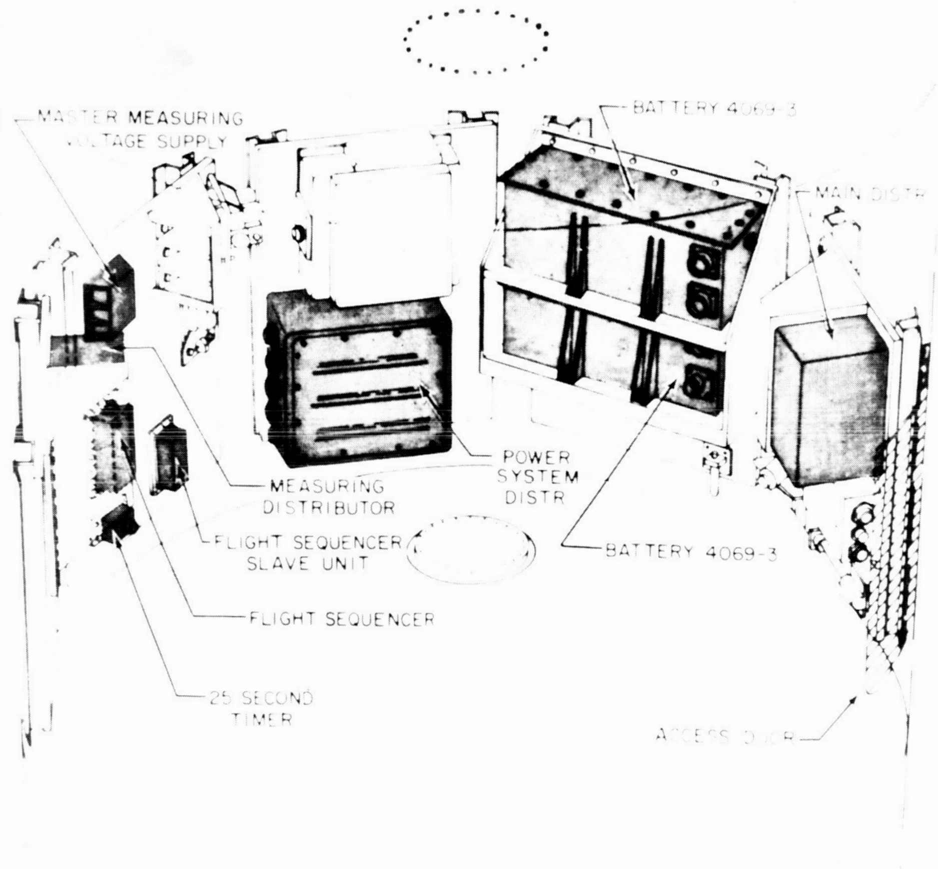


FIGURE 8. S-I STAGE INSTRUMENT COMPARTMENT ABOVE FUEL TANK NO. 2.

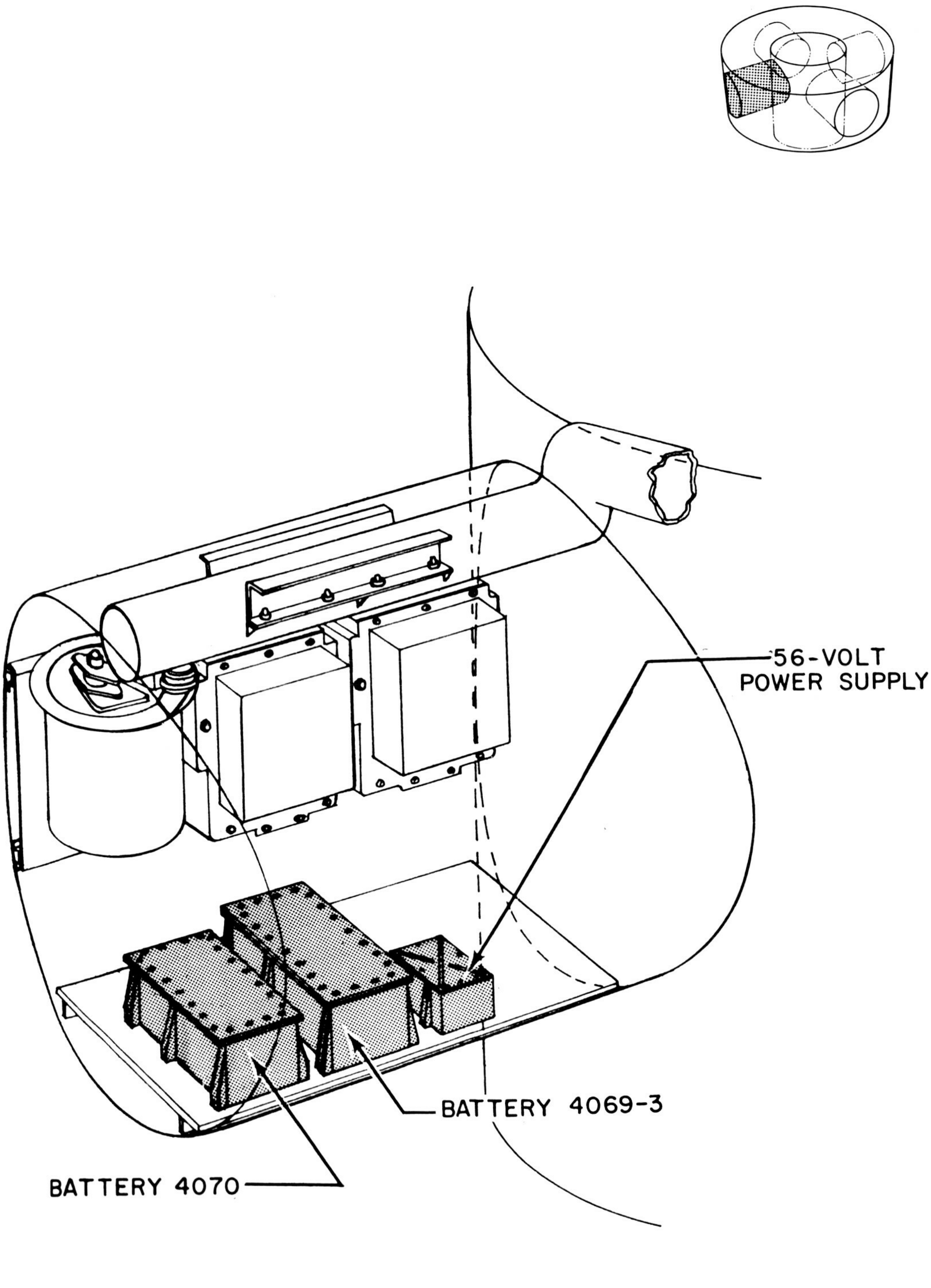
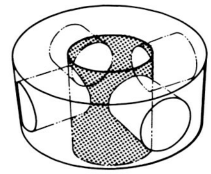


FIGURE 9. INSTRUMENT UNIT - TUBE NO. IV



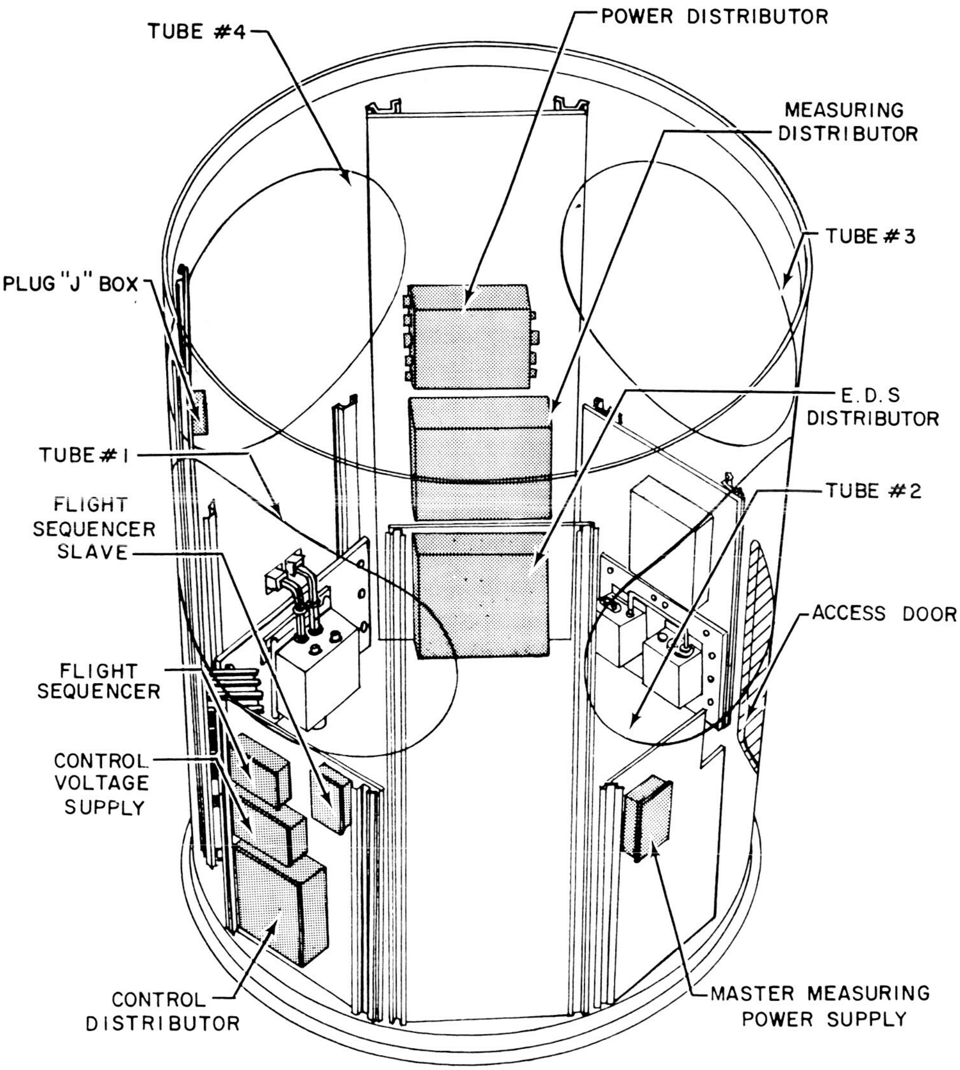


FIGURE 10. INSTRUMENT UNIT - VERTICAL CENTER CONTAINER.

FIGURE 11. E-P MAP-4069-3 BATTERY.

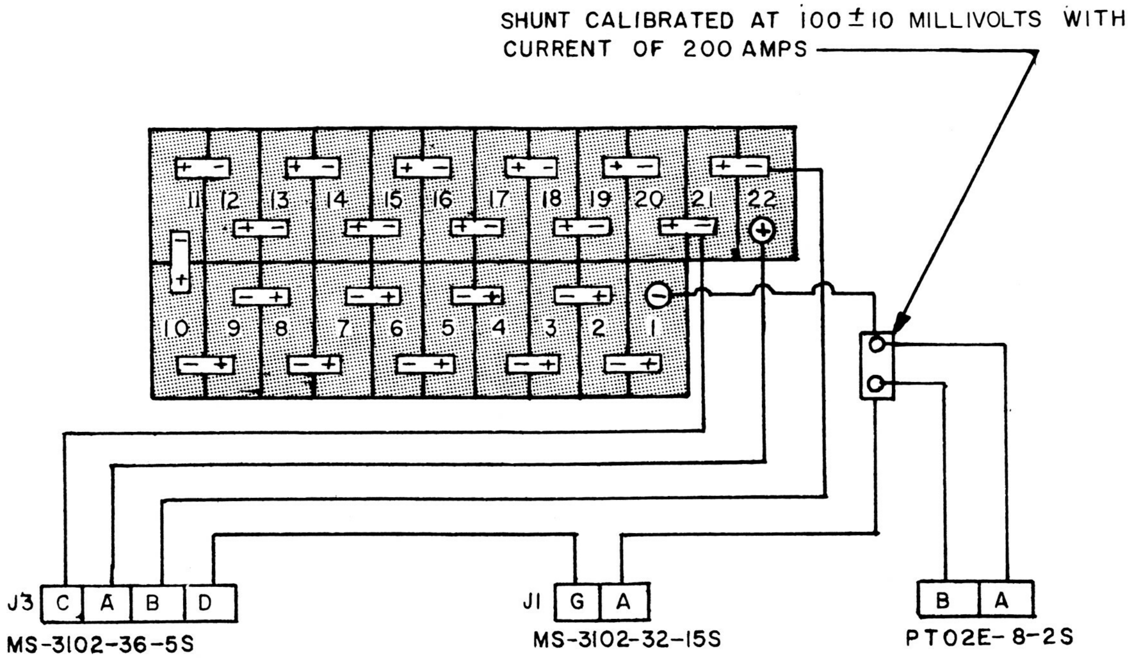


FIGURE 12. E-P MAP-4069-3 WIRING DIAGRAM.

2. <u>Type 4070 Battery (FIG. 13)</u>

A type 4070 28-volt battery, located in the Instrument Unit, supplies one-half the power requirements. The remaining power requirements are furnished by a type 4069-3 battery which has been discussed previously.

The type 4070 is an alkaline electrolyte battery in which silver-oxide and zinc are employed as the active plate materials. This battery consists of 21 cells in series (FIG. 14) with capacity to provide 1850 ampere-minutes at 28 volts when discharged at a 10 minute rate.

The battery is housed in a cast magnesium case. The individual cells are permanently affixed to the case and to each other by an epoxy-resin potting compound. Access to the cells for purposes of activation is made by removing the cover plate of the battery case. A vent tube in the battery case relieves internal pressure if any gas is generated. Excessive gassing does not occur when the battery is used within its current and capacity ratings, but might occur under conditions of a severe overload, such as a short circuit.

The battery is manually activated by filling each cell with exactly 85 cc of potassium hydroxide in water (30% solution). The specific gravity of this solution should be 1.400 3 at 25°C. After activation, the battery has a nominal standby time of 72 hours at 51.6°C. The unit is shipped in a dry-charged condition in a desiccated container.

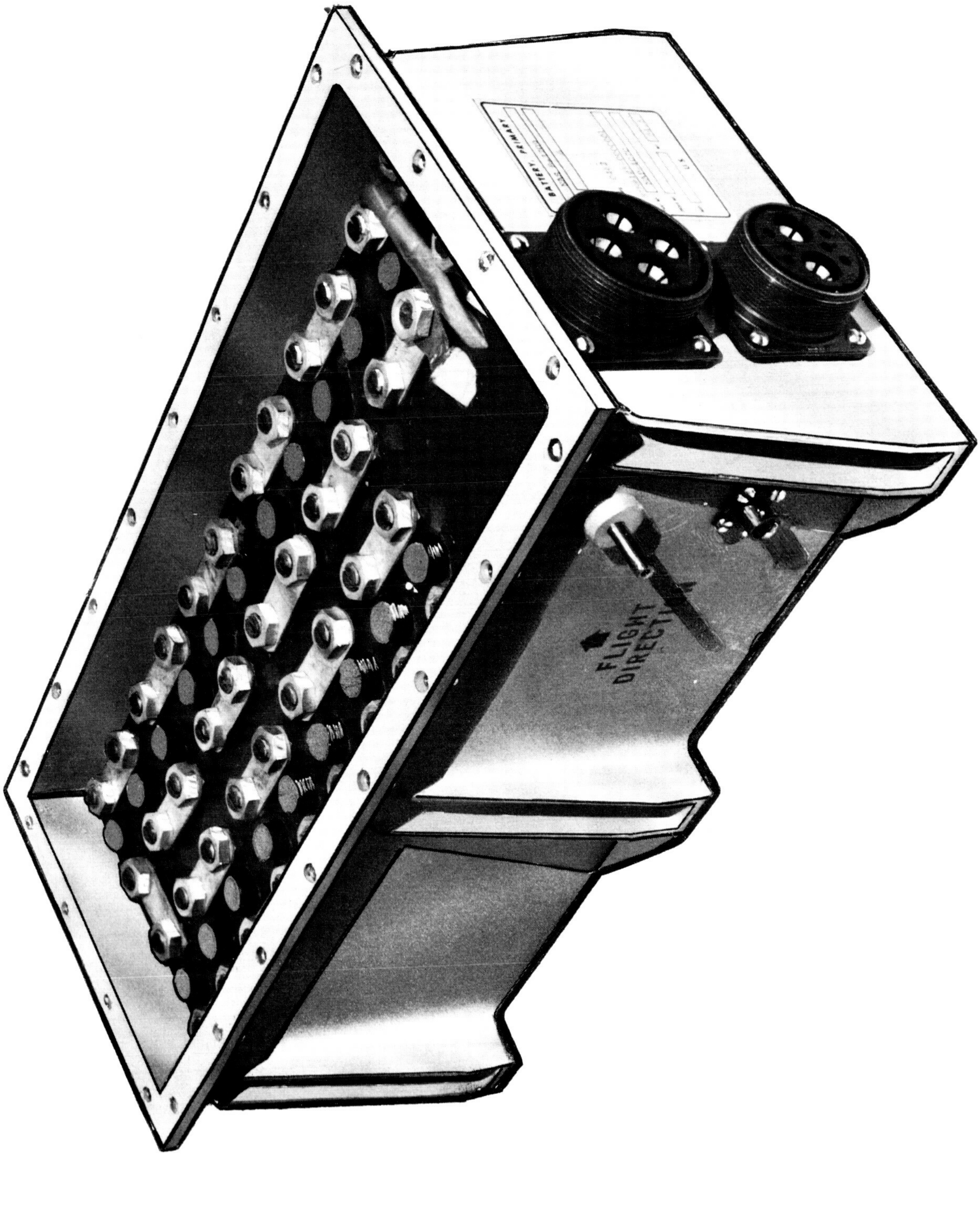


FIGURE 13. E-P MAP-4070 BATTERY.

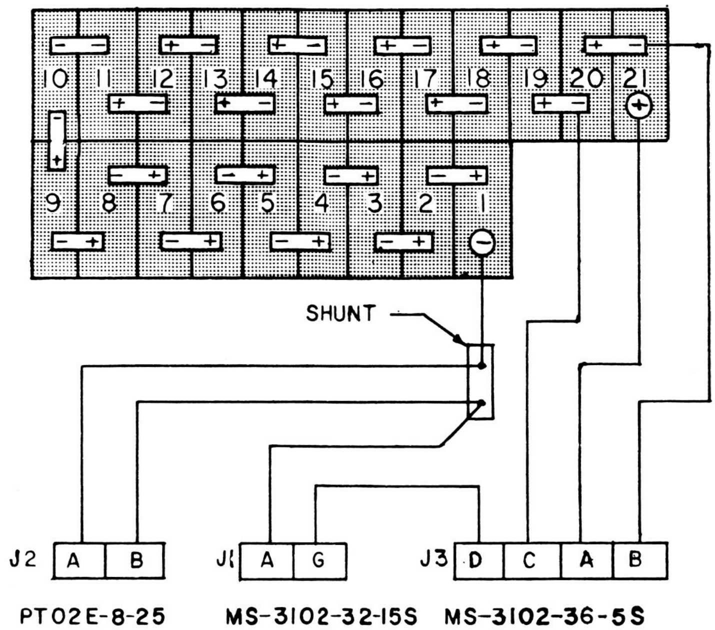


FIGURE 14. E-P MAP-4070 WIRING DIAGRAM.

The batteries measure 48.66 cm by 22.86 cm by 17.15 cm, including connectors and other external hardware. Each of the batteries weighs approximately 25 kg when activated for flight use.

B. POWER SUPPLIES

1. Control Voltage 60-Volt Power Supply (FIG. 15)

The control voltage supply is a static converter used to furnish a highly filtered and precisely regulated reference signal to the control system command and feedback potentiometers for guidance and control of the vehicle. This voltage supply, located in unit 802 center, is 18.08 cm by 28.28 cm by 12.07 cm and weighs 4.8 kg. The voltage supply requires 3-phase, 400 Hz, 115 V a.c. line-to-line input from the inverter and provides a regulated d.c. output of 60 volts ±0.25% and a current capacity of 0 to 2 amperes.

FIGURE 16 shows the block diagram of the control voltage supply. The input power is fed into filters inserted in series with each phase to reduce transients. The filtered signal is then fed into the input transformer. This transformer is a 3-phase step-down unit connected delta-delta to produce approximately 90 volts input to the rectifier circuit. Each phase is connected for full wave rectification. The output is connected across the balanced bridge regulator and also to the gate winding of the magnetic amplifier. The control winding of the magnetic amplifier is inserted

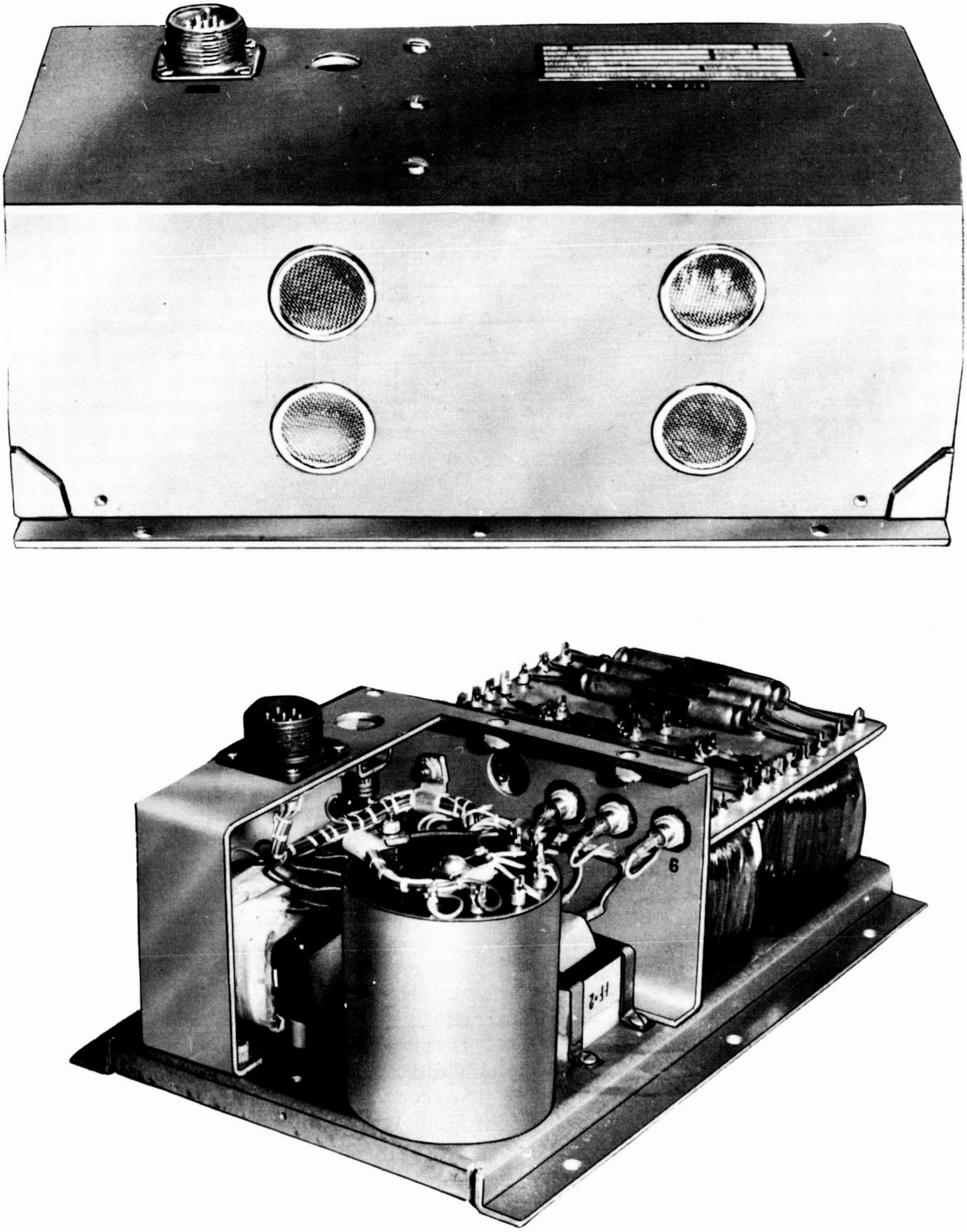


FIGURE 15. CONTROL VOLTAGE SUPPLY.

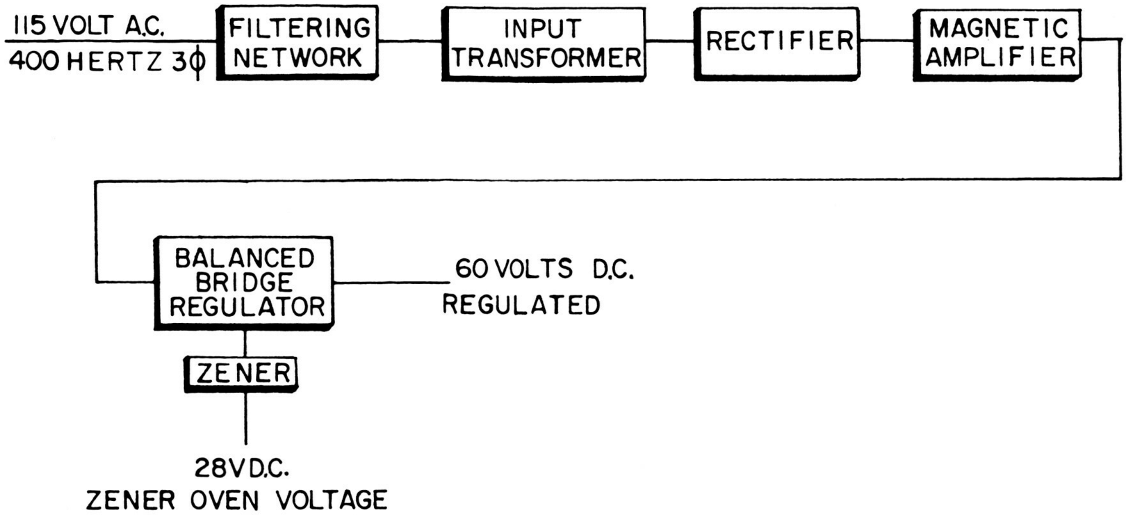


FIGURE 16. BLOCK DIAGRAM OF CONTROL VOLTAGE SUPPLY.

across the balanced bridge for output regulation. Eight zener diodes are connected in series to provide a reference voltage for the bridge. Seven of these zener diodes are in a temperature controlled oven and the eighth zener diode is located outside the oven and is used for calibration purposes. Regulation of the output voltage of the supply is achieved by the magnetic amplifier and the reference provided by the zeners in the bridge circuit. Control is accomplished by the direction of the current flow in the control winding in conjunction with the balanced bridge circuit. If the output voltage increases, current flow in the bridge unbalances, thus producing an increase in the zener current and in the control winding. This action advances the firing angle of the gate winding with a subsequent decrease in the supply output voltage. If the output voltage decreases, the current flow in the bridge is unbalanced in the opposite leg of the bridge and results in a reversal of the control winding current. This action provides a delay of the firing angle of the gate winding and results in an increase of the supply output voltage.

2. Measuring Voltage Supply Modules (FIG. 17)

Eight measuring voltage supplies are in each of the Saturn SA-5 through SA-7 vehicles. Two of these d.c. to d.c. converters are mounted in each of the four measuring distributors located in unit 9 of the S-I stage. Each converter supplies a precisely regulated d.c. reference voltage to a separate engine system to be used in conjunction with the telemetry system to monitor inflight engine performance. This reference voltage is 5 V d.c. regulated to 15 mV at a rated output of 100 mA. Each voltage supply is 8.1 cm by 5.0 cm by 6.2 cm and weighs approximately 315 grams.

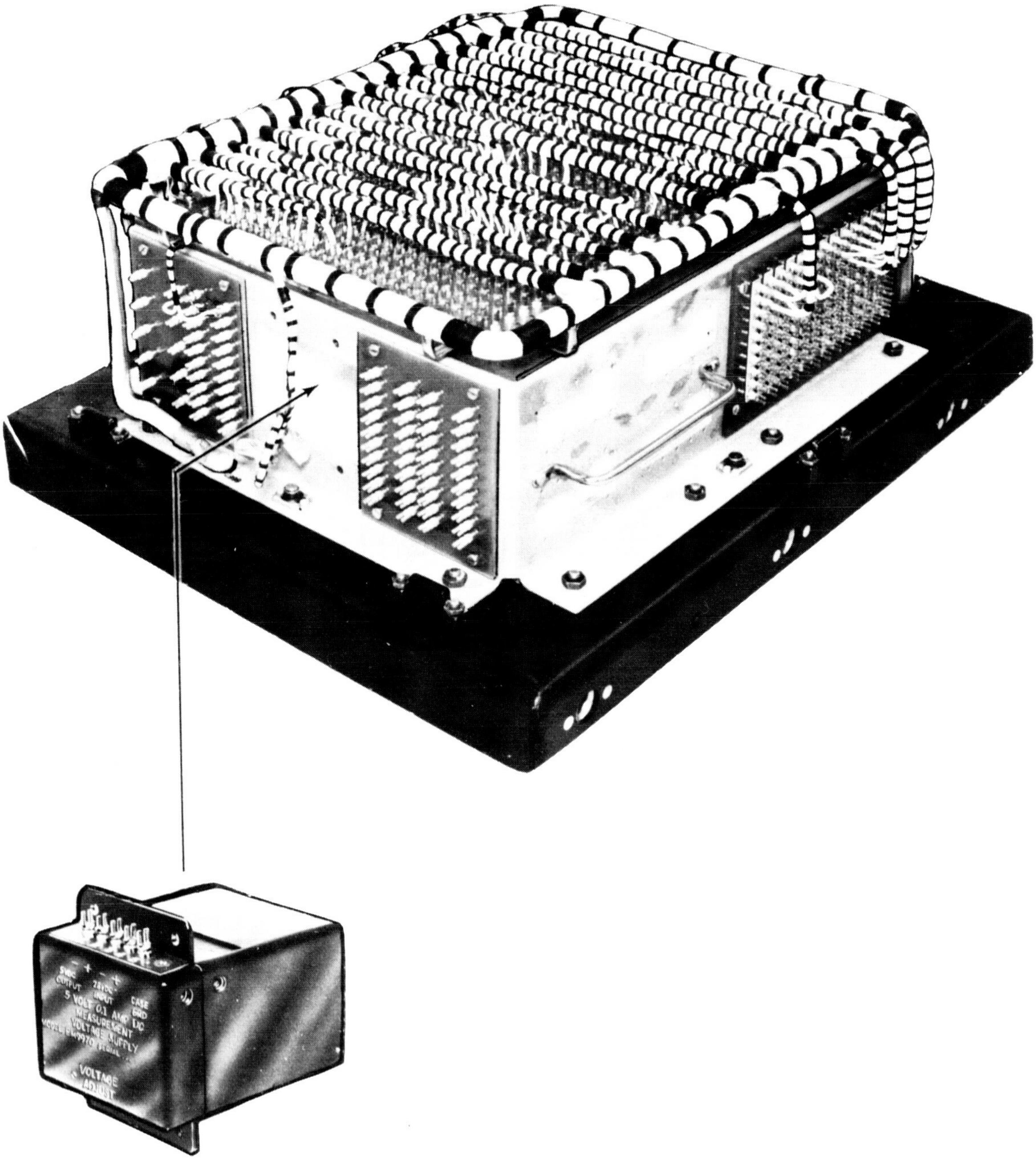


FIGURE 17. MEASURING DISTRIBUTOR AND 5-V MEASURING VOLTAGE SUPPLY MODULE.

Each of the converters energizes potentiometers and other sensing devices for an individual engine system and provides an independent and electrically-isolated telemetry reference. This provides a safety factor since one or more of the engine systems or the converters can fail and not affect the other.

FIGURE 18 shows the block diagram of the measuring voltage supply module. The measuring voltage supply converts a 24 to 32 volts d.c. input to a precise 5-volt output for a load range of 0 to 100 mA.

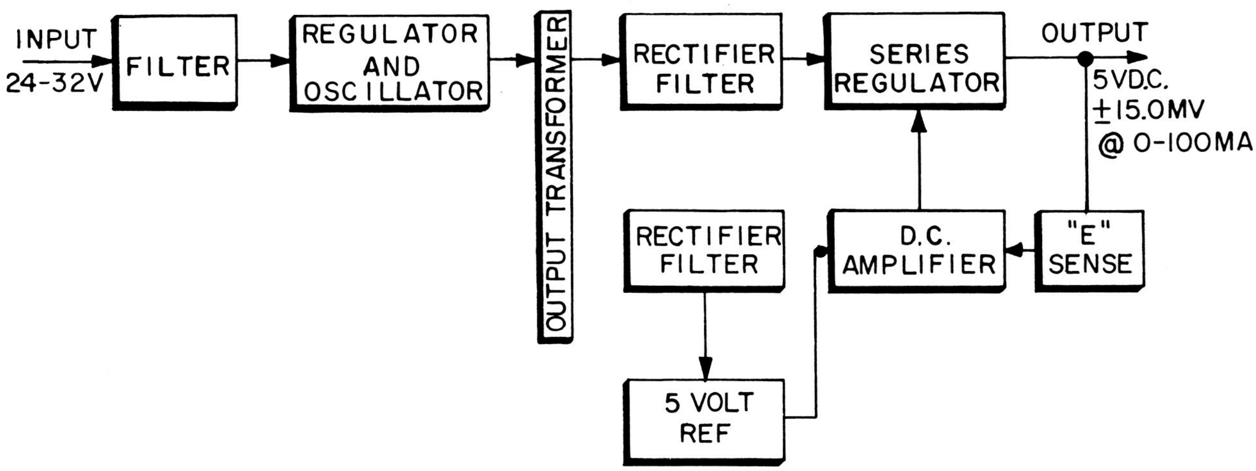


FIGURE 18. BLOCK DIAGRAM OF MEASURING VOLTAGE SUPPLY MODULE.

The input voltage is fed into a series regulator and switching oscillator combination. The output transformer of this oscillator has two windings. The main winding, a nominal 8 volts, is rectified and filtered; then it is applied to the input of a series regulator. One winding is used for a precise reference. The output of the reference winding is compared with the 5-volt output voltage supply and the difference between them is then fed to a high-gain, high-frequency response d.c. amplifier. The output of this amplifier is fed into the series regulating transistor. The amplitude of this voltage controls the forward voltage drop of this transistor and regulates the output voltage.

To insure the regulation that is required for this voltage supply, voltage sensing will take place at the output connector. By sensing at this point, all line and connector voltage drops will be taken into consideration and will not affect the performance of the power supply.

3. Master Measuring Voltage Supply (FIG. 19)

The master measuring voltage supply is a d.c. to d.c. converter operated from the 28-volt bus. It delivers a precisely regulated

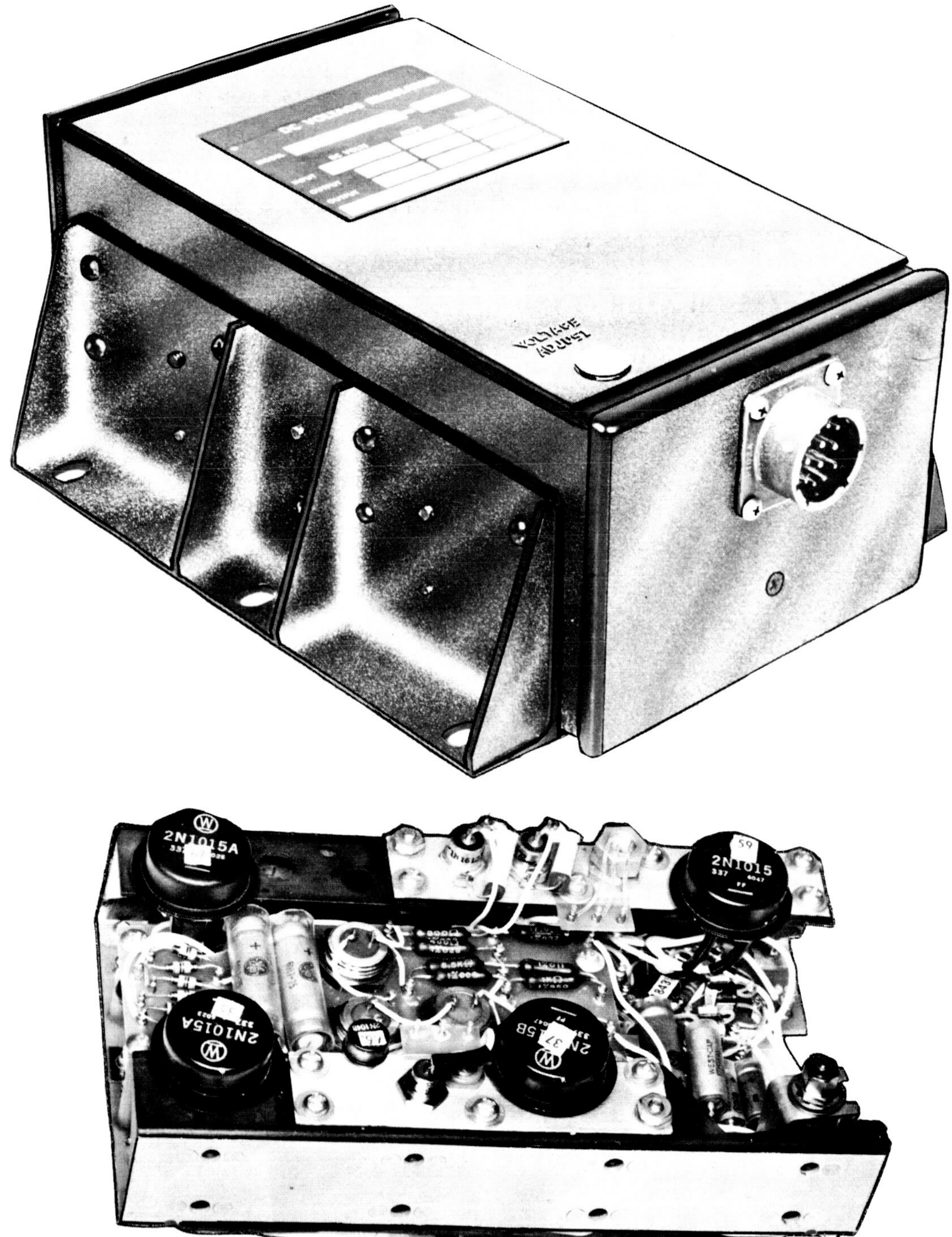


FIGURE 19. MASTER MEASURING VOLTAGE SUPPLY.

5 V d.c. to loads between zero and one ampere. The entire unit was designed to compensate to within 12.5 mV for any combination of load variations, input load variations, and temperature variations.

Two identical master measuring voltage supplies are located in the SA-5 through SA-7 vehicles. One is located in unit 12 of the S-I stage and the other is located in the Instrument Unit. The master measuring voltage supply provides a reference to measuring racks and measuring distributors. These measuring racks and distributors furnish vehicle measuring devices with the 5 V d.c. reference voltage on which telemetry measurements are based.

The dimensions of this unit are 12.7 cm by 20.3 cm by 8.3 cm; it weighs 1.82 kg.

FIGURE 20 shows a simplified block diagram of the Saturn master measuring voltage supply. The input regulator consists of a radio frequency filter to keep noise generated within from reflecting to the input line and a series regulator type filter to keep large transients on the input line from affecting the voltage supply operation.

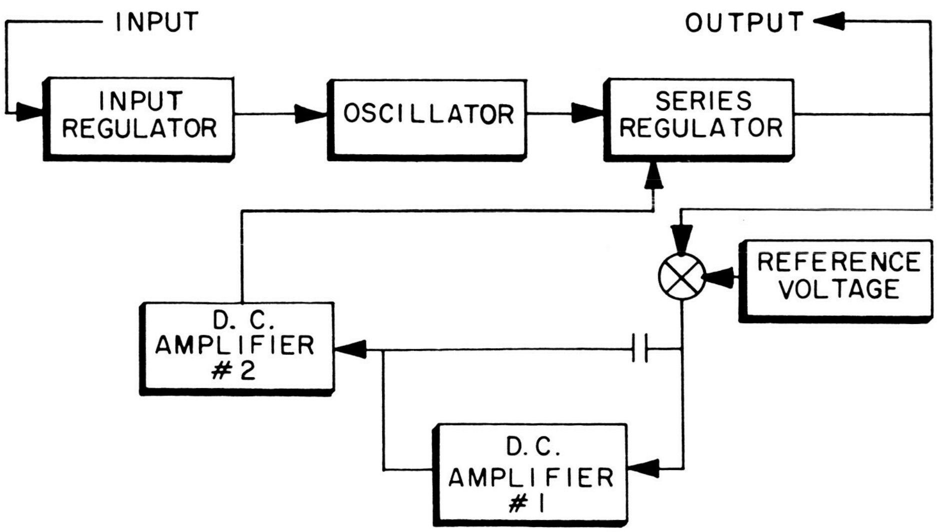


FIGURE 20. BLOCK DIAGRAM OF MASTER MEASURING VOLTAGE SUPPLY.

The oscillator circuit provides short circuit protection for the unit. If a short circuit developed, the load would reflect causing the oscillator to cease oscillating, thus protecting the circuitry within the unit.

The series regulator, reference voltage circuit, and d.c. amplifiers #1 and #2 are combined to form the output regulator. This output regulator uses a remote sense circuit (voltage reference) to keep the output impedance

as low as possible. The d.c. amplifier #1 is a chopper type of amplifier with extremely high d.c. stability which employs matched transistors for circuit balance. Amplifier #1 provides low frequency response while amplifier #2 provides high frequency response.

If the output voltage increases, the reference circuit (FIG. 21) will sense the increase at a summing point. The increase in voltage when amplified by d.c. amplifier #1 and #2 will affect the transistor bias in the series regulator circuit and bring the output back to its specified limits. CR2 and CR3 in the reference circuit provide double regulation for better output stability.

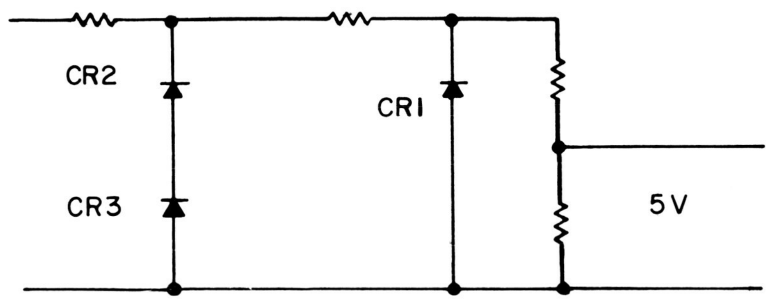


FIGURE 21. REFERENCE CIRCUIT FOR MASTER MEASURING VOLTAGE SUPPLY.

4. <u>56-Volt Power Supply (FIG. 22)</u>

The 56-volt power supply is a d.c. to d.c. converter used to furnish a controlled voltage to the torque amplifier of the ST-124 platform. The input of the power supply is 28 V d.c. and the output is 56±3 volts from no load to full load of 10 amperes. One 56-volt power supply is located in the Instrument Unit of the vehicle. Its dimensions are 13.9 cm by 21.6 cm by 10.2 cm; it weighs 5.3 kg.

FIGURE 23 shows a simplified block diagram of the 56-volt power supply. The power supply makes use of a push-pull oscillator in which the square wave a.c. output is fed through a magnetic amplifier to a driver amplifier. The output of the driver amplifier supplies the power necessary to drive the bases of the power amplifier. The output of the power amplifier is then rectified, with the negative leg connected in series with the positive of the battery. The reason for connecting the battery in series with the power supply output is to raise the overall efficiency of the unit. The resulting output is then filtered before being applied to the load. This output is applied to a reference bridge with a proportion of this signal fed back to the magnetic amplifier. By controlling the amount of current flowing in the control winding of the magnetic amplifier, pulse width modulation or control of the output voltage is obtained.

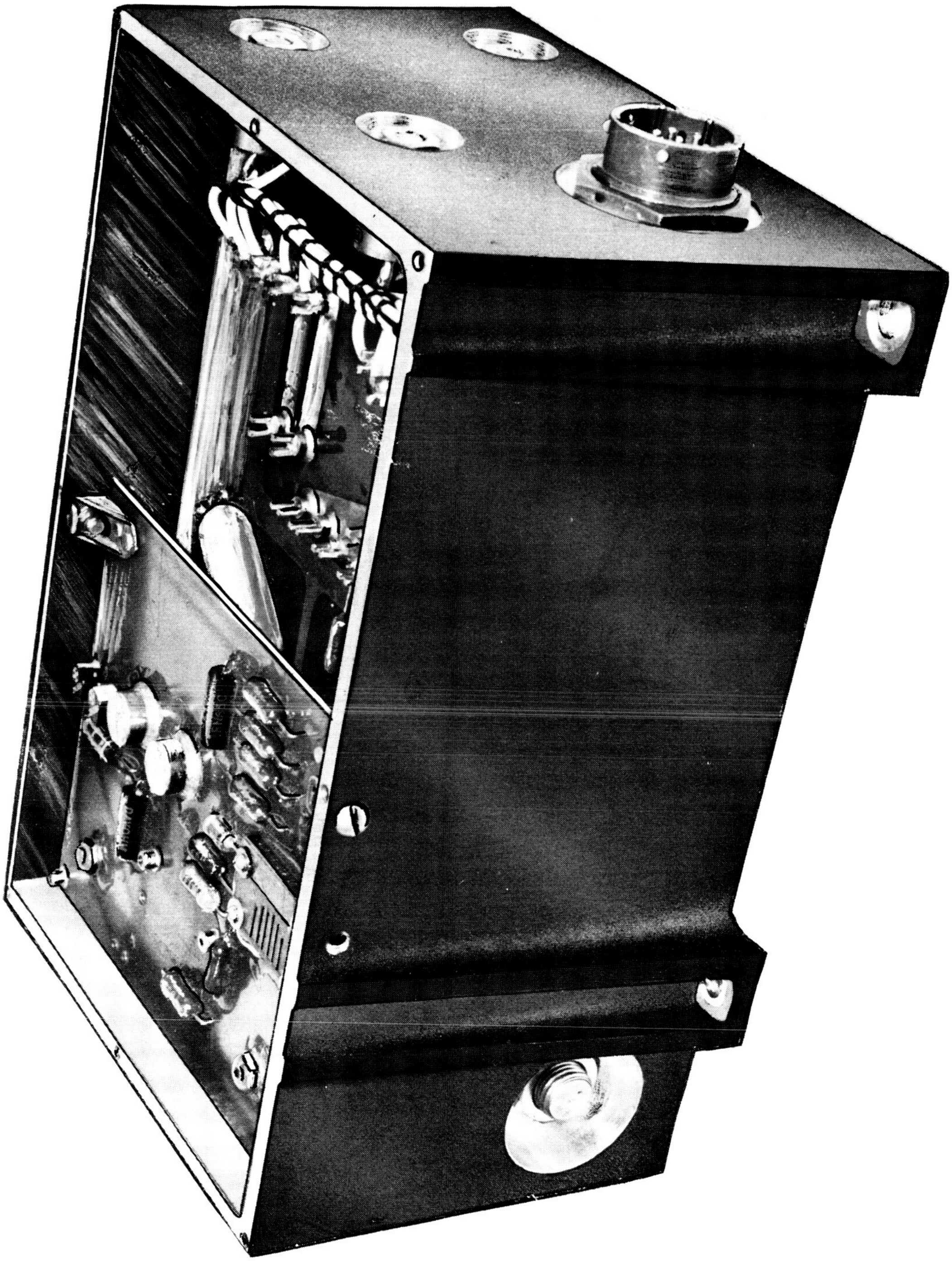


FIGURE 22. 56-VOLT POWER SUPPLY.

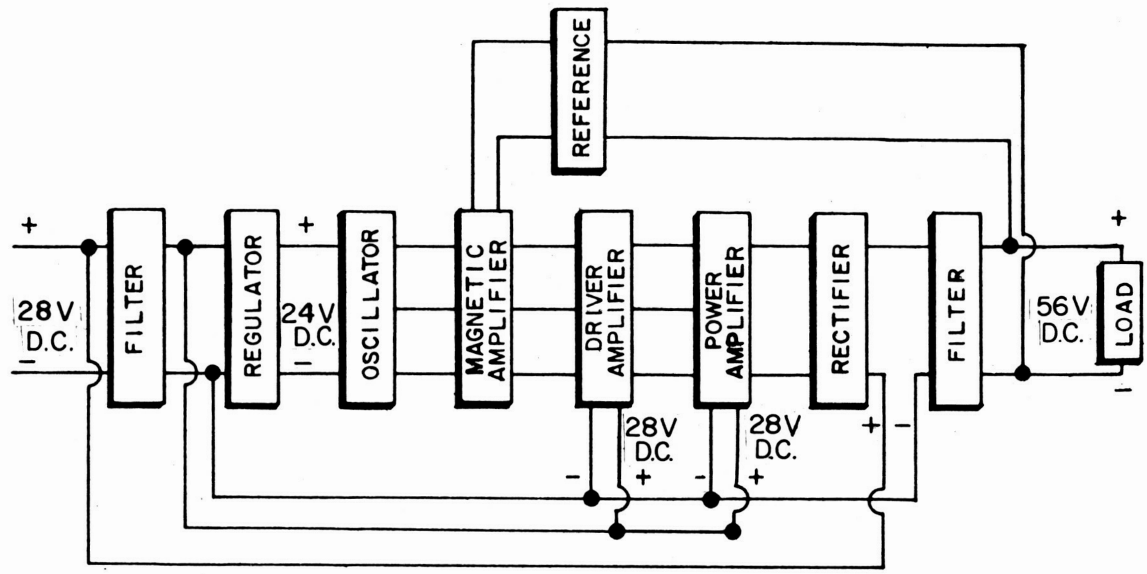


FIGURE 23. BLOCK DIAGRAM OF 56-VOLT POWER SUPPLY.

5. Strobe Light Power Supply (FIG. 24)

The strobe light power supply is a static converter used to furnish 2400 volts at a constant current of 150 mA to the strobe light. There are two strobe light power supplies, one for each of the two strobe lights. Both the power supplies and the strobe lights are located in the S-IV interstage. The dimensions of the power supply are 15.2 cm by 27.9 cm by 22.9 cm; the weight is 10.9 kg.

The input voltage to the strobe light power supply is 28 V d.c. at 18 amperes supplied by a 28-volt bus from the S-I stage. The output of the power supply is a ramp function of 2400 volts peak; the frequency of this ramp is 16 Hz.

FIGURE 25 shows a simplified block diagram of the strobe light power supply. The 28 V d.c. is filtered by the line filter to eliminate noise that may be introduced. This filtered voltage powers the oscillator and the power amplifier. The bases of the power amplifier transistors are driven by the oscillator. An output of 200 V d.c. is taken directly from the power amplifier and fed to the trigger circuit located in the strobe light. A second output of the power amplifier is fed directly into the saturable reactor. The function of the saturable reactor is to maintain the output current constant from 0 to 2400 volts. The output of the saturable reactor is then fed into a high voltage transformer which raises the output voltage to the desired level of 2400 volts. This

FIGURE 24. STROBE LIGHT POWER SUPPLY.

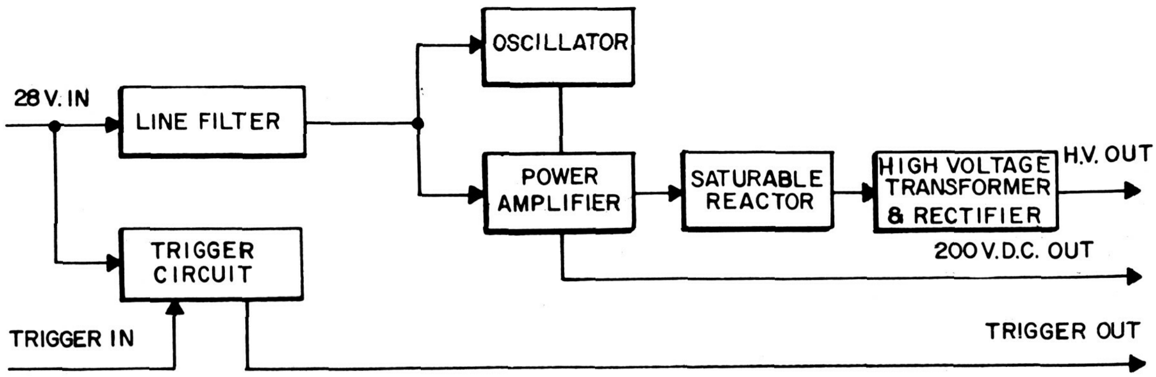


FIGURE 25. BLOCK DIAGRAM OF STROBE LIGHT POWER SUPPLY.

high voltage is rectified and cabled directly to the strobe light. The trigger circuit is used as a pulse shaper and amplifier of the camera synchronization pulses.

C. FLIGHT SEQUENCER AND SLAVE (FIGS. 26 and 27)

The flight sequencer is a relay device that functions as a step switch to program distribution of 28 V d.c. power to relays and other control actuation devices. The basic Saturn flight sequencer provides 10 steps, or distribution points, for control functions. The basic unit can be connected to one or more slave units to increase the number of steps in multiples of ten. For Saturn use, the flight sequencer is used with a single slave unit to provide 20 steps or distribution points.

Physically, the flight sequencer consists of relays, diodes, and two printed circuit boards. Two Bendix pigmy-type connectors provide external terminations. Small components are rigidly affixed to the printed circuit boards by conformal coating. The external dimensions of the flight sequencers are 23.6 cm by 11.7 cm by 6.5 cm. The weight is 1.36 kg.

Electrical inputs to the unit include the pulses from the program device and a positive 28 V d.c. input. The 28 V d.c. input is applied to a common bus from which application of power to various elements of the vehicle is made through relay contact closure. Each pulse from the program device energizes one relay and arms the second relay. Thus as each relay is consecutively energized, the unit operates as a step switch. The relays used for stepping functions are a crystal can, latching type; once energized, they remain in that position until electrically reset. When used with the slave unit, the last relay of the flight sequencer must actuate before the slave unit relays can be energized.

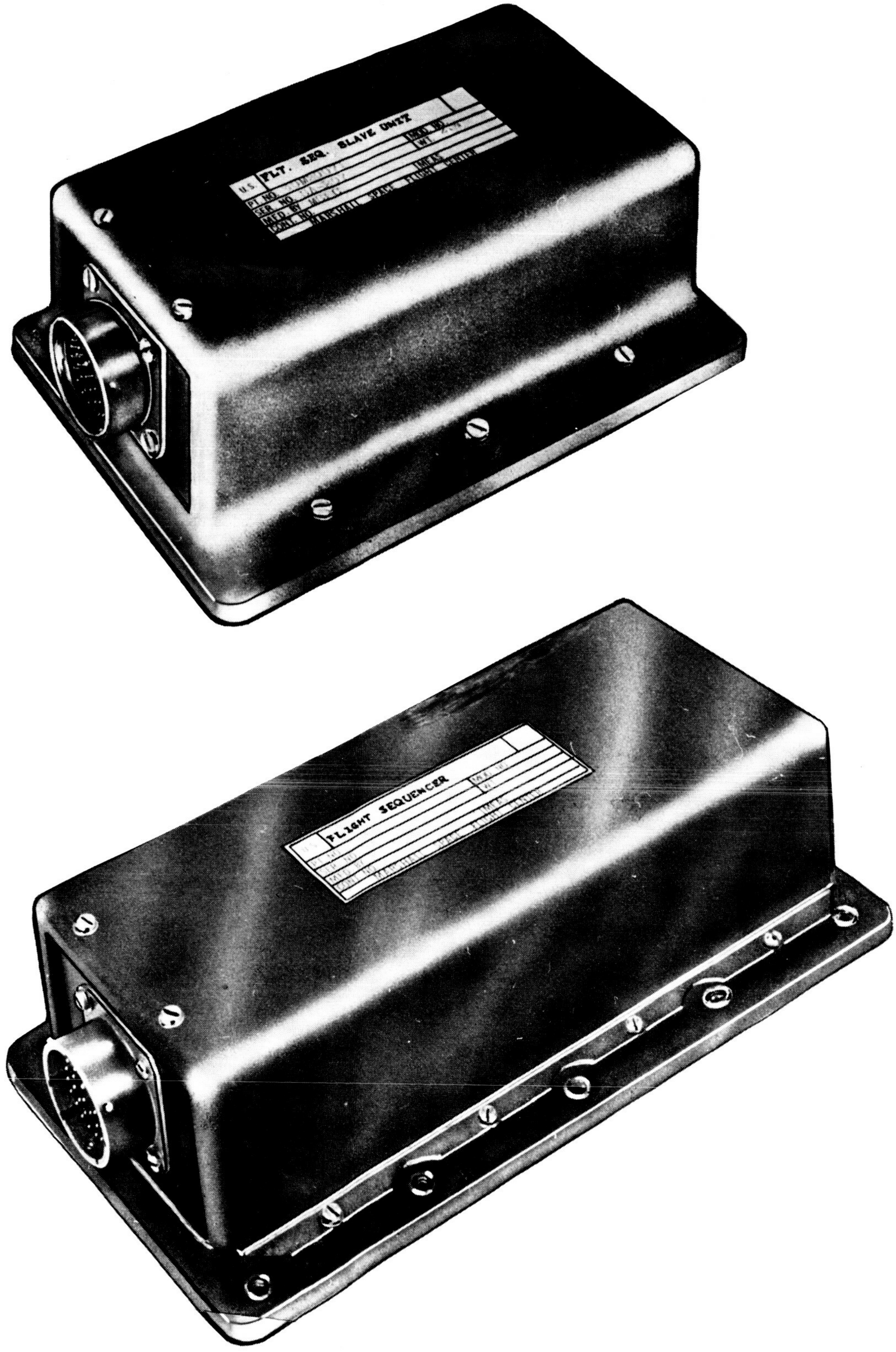


FIGURE 26. FLIGHT SEQUENCER AND SLAVE (EXTERNAL).

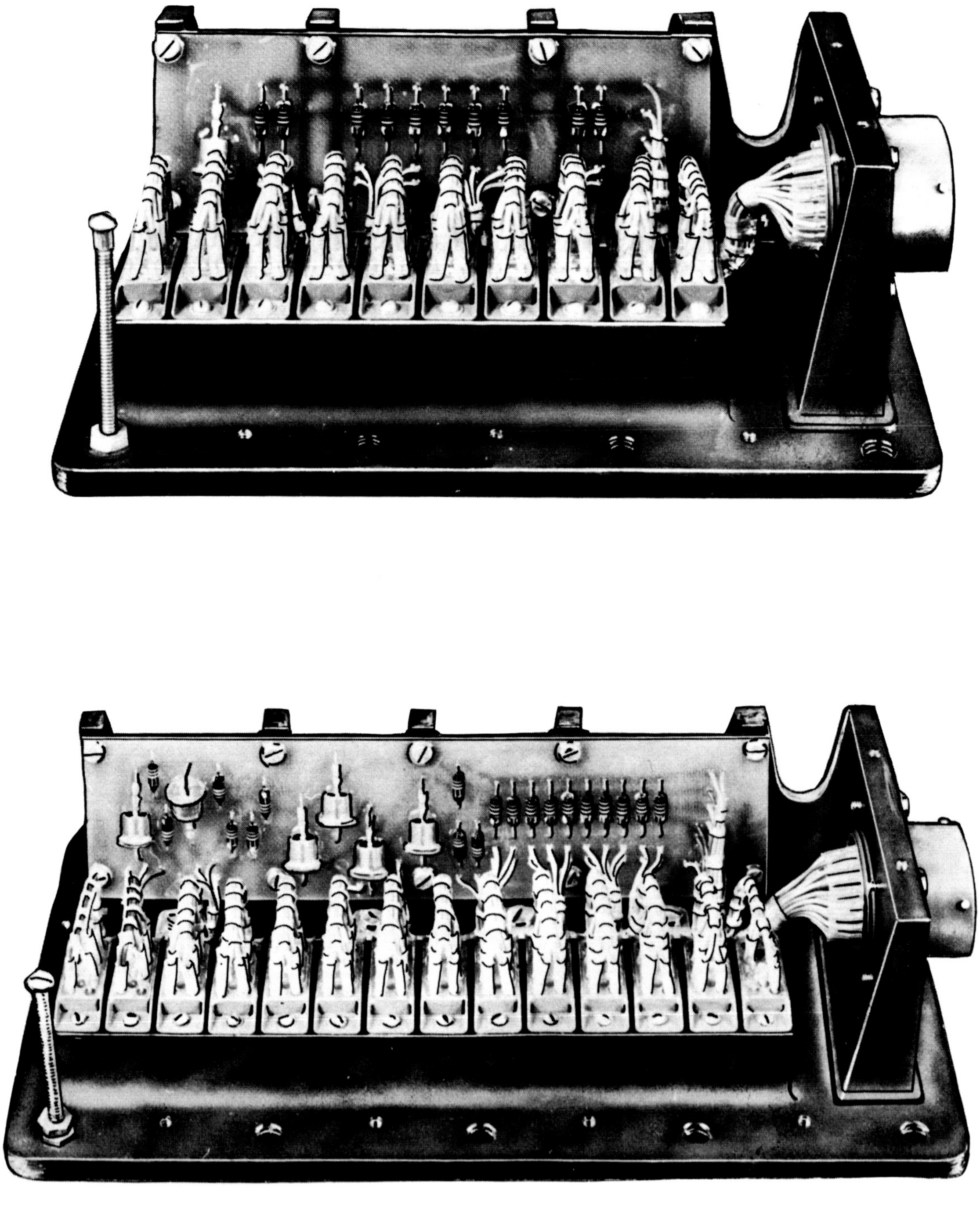


FIGURE 27. FLIGHT SEQUENCER AND SLAVE (INTERNAL).

The slave unit contains only ten relays and uses the basic flight sequencer switching circuitry to operate these relays. Construction, design, and components of the slave unit are almost identical to the flight sequencer, and tests indicate the slave units reliability is as good or better than the main unit. The slave unit utilizes three Bendix connectors for input, output, and a second slave unit to be connected. Its dimensions are 18.5 cm by 11.7 cm by 6.5 cm; it weighs 1.07 kg.

A flight sequencer and slave unit are located in unit 12 to provide sequenced, network-switching functions for the S-I stage. There is also an identical flight sequencer and slave unit located in unit 802 center to provide sequenced, network-switching functions for the Instrument Unit.

D. DISTRIBUTORS

1. Power Distributors (FIG. 28)

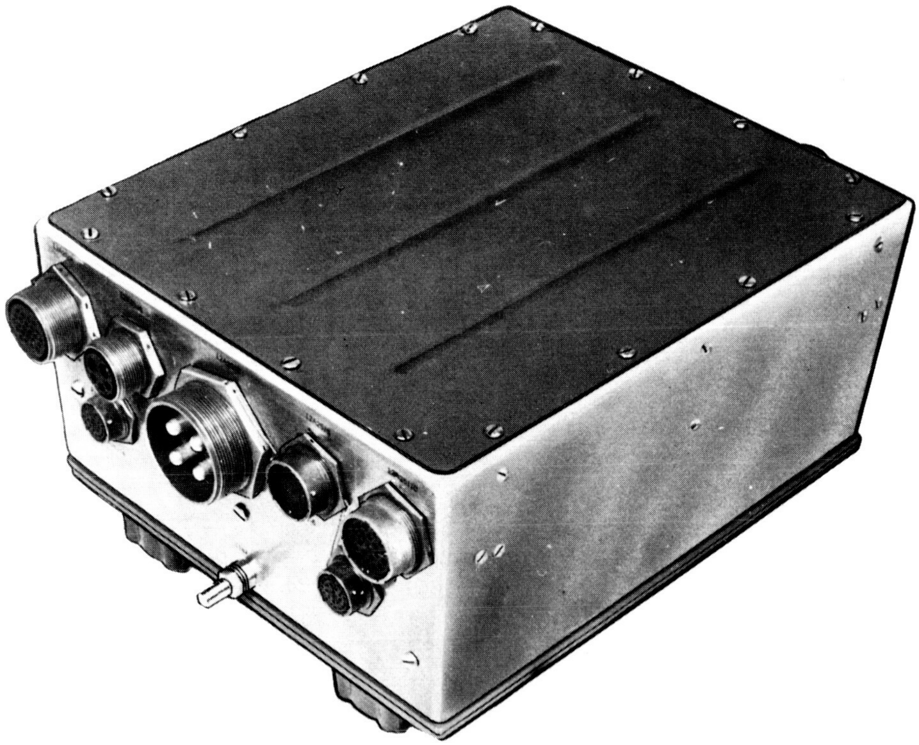
The Saturn 28-volt batteries supply main power to the power distributors which are used to switch and distribute power as required for operating all inflight subsystems. There are two power distributors used; one is located in unit 12 of the S-I stage and the other is located in the Instrument Unit. Both distributors measure approximately 35 cm by 33 cm by 20 cm and weigh approximately 17 kg. The distributor in unit 12 has 14 connectors and two terminal boards. It also contains four 200 ampere relays which connect the vehicle batteries to power busses. Four other relays, rated at 50 amperes, switch power to the camera, the inverter, and the liquid-level racks. Ten additional relays, rated at 7.5 amperes, distribute power to telemeter links. Two latching relays, rated at 2.0 amperes, are utilized for circuit control. FIGURE 29 shows a typical circuit through a power distributor.

2. Measuring Distributors (FIG. 30)

Six measuring distributors are located in the Saturn SA-5 through SA-7 vehicles. Four are located in unit 9, one in unit 12 of the S-I stage, and one in unit 802 center of the Instrument Unit.

All six of these distributors are similar in configuration. Distributors 9A3, 9A4, 9A5, and 9A6 are identical except for wiring and number of components used; distributors 12A26 and 802A3 are identical except for wiring and number of components used. Both types are identical in configuration except for the connector face plate.

Each distributor is housed in a case which is approximately 18 cm by 31 cm by 36 cm, including the connectors and other hardware. The distributors weigh between 9.1 and 11.3 kg, varying slightly according to the differences in electrical hardware.



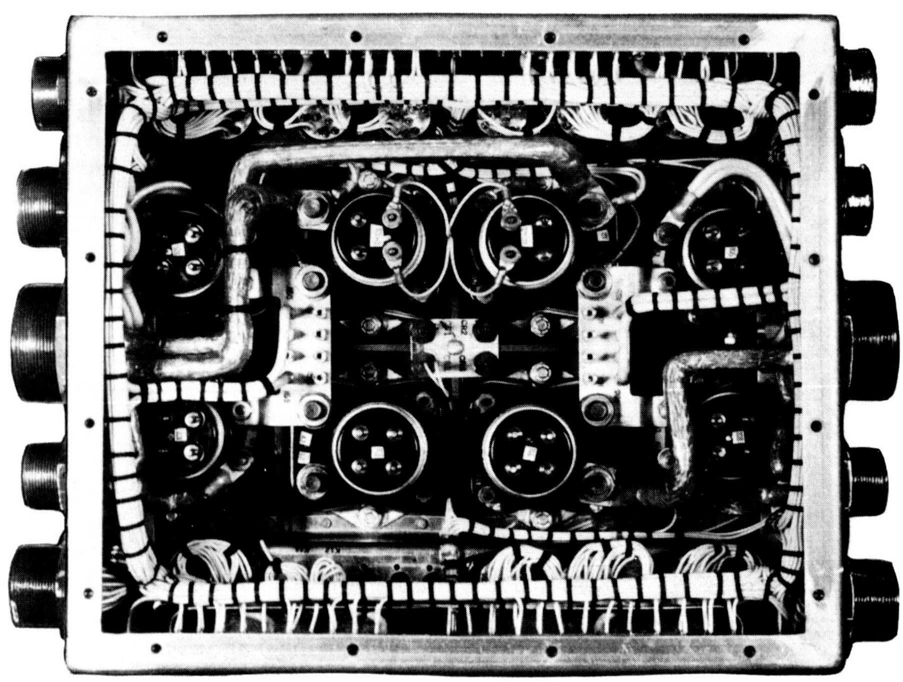


FIGURE 28. POWER DISTRIBUTOR.

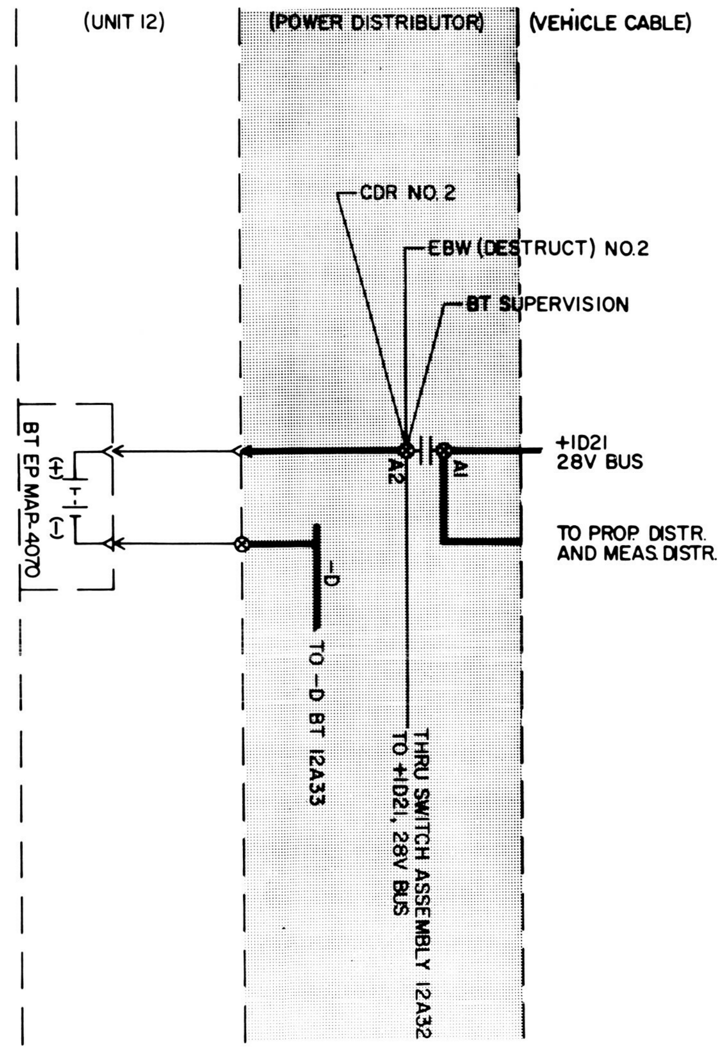


FIGURE 29. CIRCUIT THROUGH POWER DISTRIBUTOR.

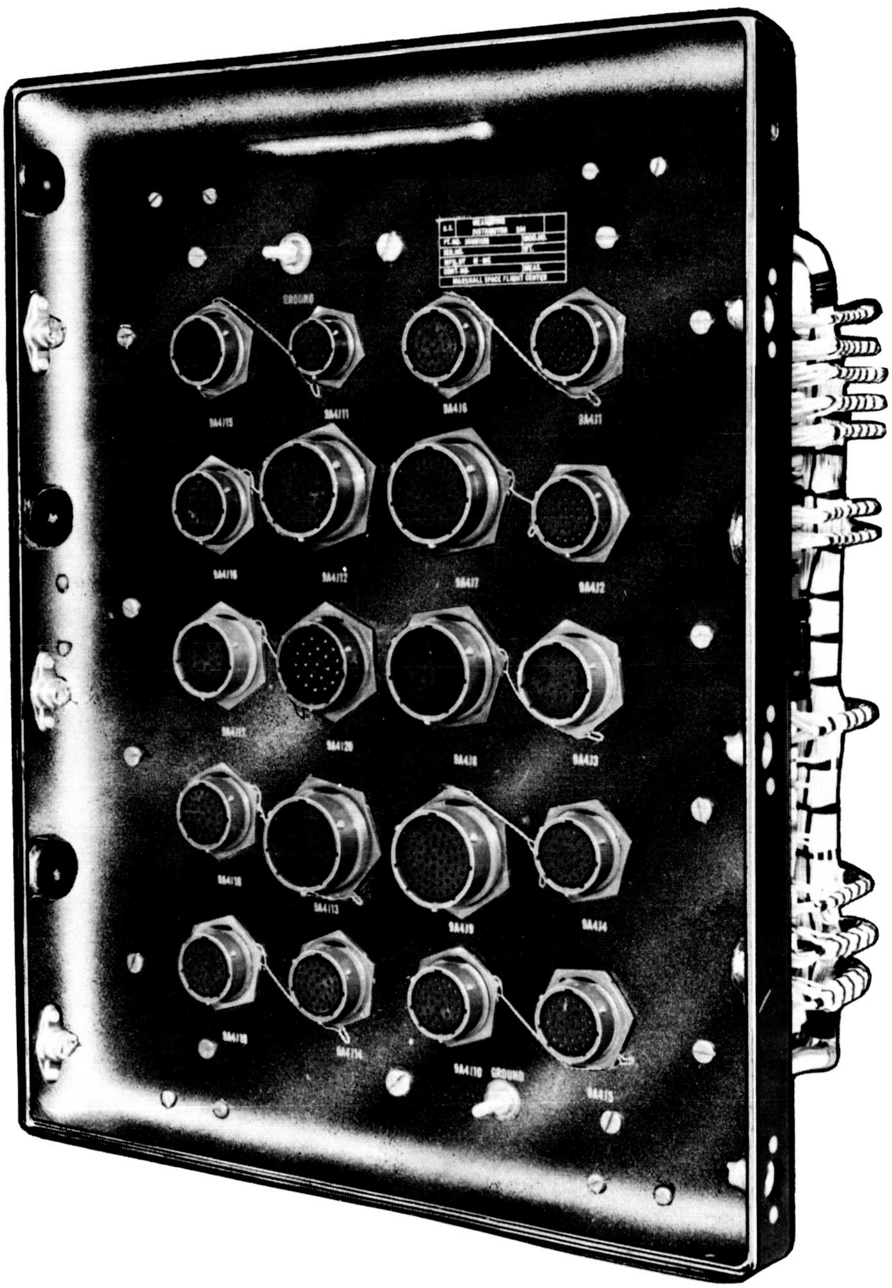


FIGURE 30. MEASURING DISTRIBUTOR.

The measuring distributors transmit measurement signals to the telemeter channels from the engines, the tail area, and the upper portion of the vehicle. The locations and functions of these distributors are:

a. Measuring distributor 9A3, located in unit 9, controls direct measurements and measurements on engines 1 and 5 and on unit 16 (Fin I).

b. Measuring distributor 9A4, located in unit 9, controls direct measurements and measurements on engines 2 and 6 and on unit 18 (Fin II).

c. Measuring distributor 9A5, located in unit 9, controls measurements on engines 3 and 7 plus a portion of the measurements in unit 9.

d. Measuring distributor 9A6, located in unit 9, controls measurements on engines 4 and 8, racks, a portion of unit 9, and the lower part of unit 10.

e. Measuring distributor 12A26, located in unit 12, controls all measurements in units 11, 12, and 13 and the upper part of unit 10. It also controls all telemeter equipment in the S-I stage.

f. Measuring distributor 802A3, located in unit 802 center of the Instrument Unit, controls all measurements located in the Instrument Unit of the vehicle.

Each distributor has 20 connectors which are located on the base plate of the case. The connector pins are wired to a terminal board located on the upper side of the distributor opposite the connectors. The wires leading through the distributor from the connector pins to the terminals are potted with lockfoam to reduce possible vibration damage to the distributor circuitry. Jumpers between terminals, relays, and various pins are applied on the upper side of the terminal boards. This allows convenient access to the circuits when incorporating changes in the system.

The 28 V d.c. power from the vehicle batteries is supplied through the power distributor to busses in the measuring distributors in the S-I stage. This 28-volt supply is fed to the measuring power supplies, converted to a 5-volt output, and routed to the measuring voltage busses. From these 5-volt busses, voltage is supplied to the various measurement pickups throughout the vehicle.

Contained within the S-I stage distributors are +1D81 through +1D89 busses, each of which is tied to one of the 5-volt power supplies. The +1D81 through +1D88 busses are used to distribute 5-volt power through the S-I measuring network to the measurements in the eight engine compartment areas. The +1D89 supplies 5-volt power to all the remaining measurements throughout the S-I. The -1D80 bus is common to all measuring

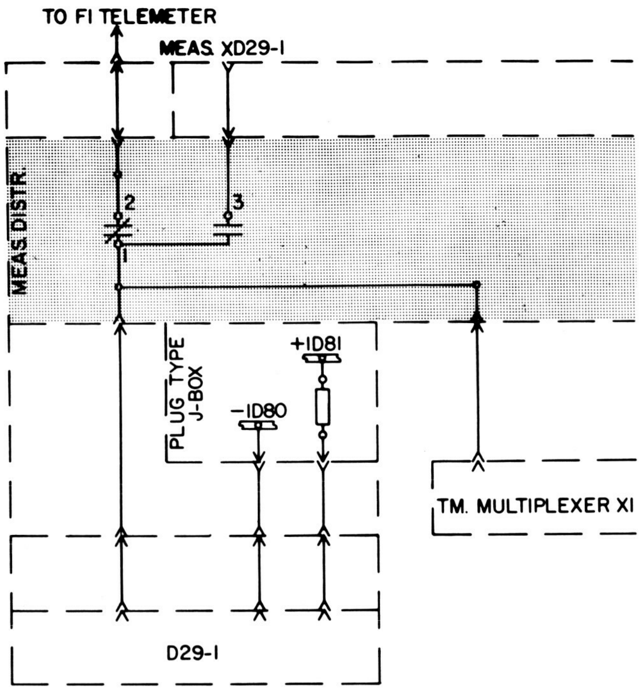


FIGURE 31. CIRCUIT THROUGH MEASURING DISTRIBUTOR.

supplies in the S-I stage. FIGURE 31 shows an example of a circuit through a measuring distributor in the S-I stage.

Measuring distributor 802A3 in the Instrument Unit also receives 28 V d.c. power from the vehicle batteries through the power distributor in the Instrument Unit. Contained within this distributor is the +8D81 bus, which supplies 5-volt power to all measurements located in the Instrument Unit.

3. Propulsion Distributor (FIG. 32)

The propulsion distributor contains the relays and circuitry that control the function of all eight engines of the S-I according to a preset, programed sequence. This distributor is located in unit 9 of the vehicle; its dimensions are approximately 36 cm by 32 cm by 19 cm, including the 19 connectors and other external hardware; it weighs 10.55 kg.

The propulsion distributor busses receive 28-volt power from the power distributor and distribute this power to the circuits and relays that control the engine functions. Some of the relays actuate fuel and LOX prevalves for controlling the flow of propellants to the engines, and some are used to activate the conax valves for engine cutoff. The engine cutoff relays are activated when signals are received from the flight sequencer or from sensors indicating low thrust.

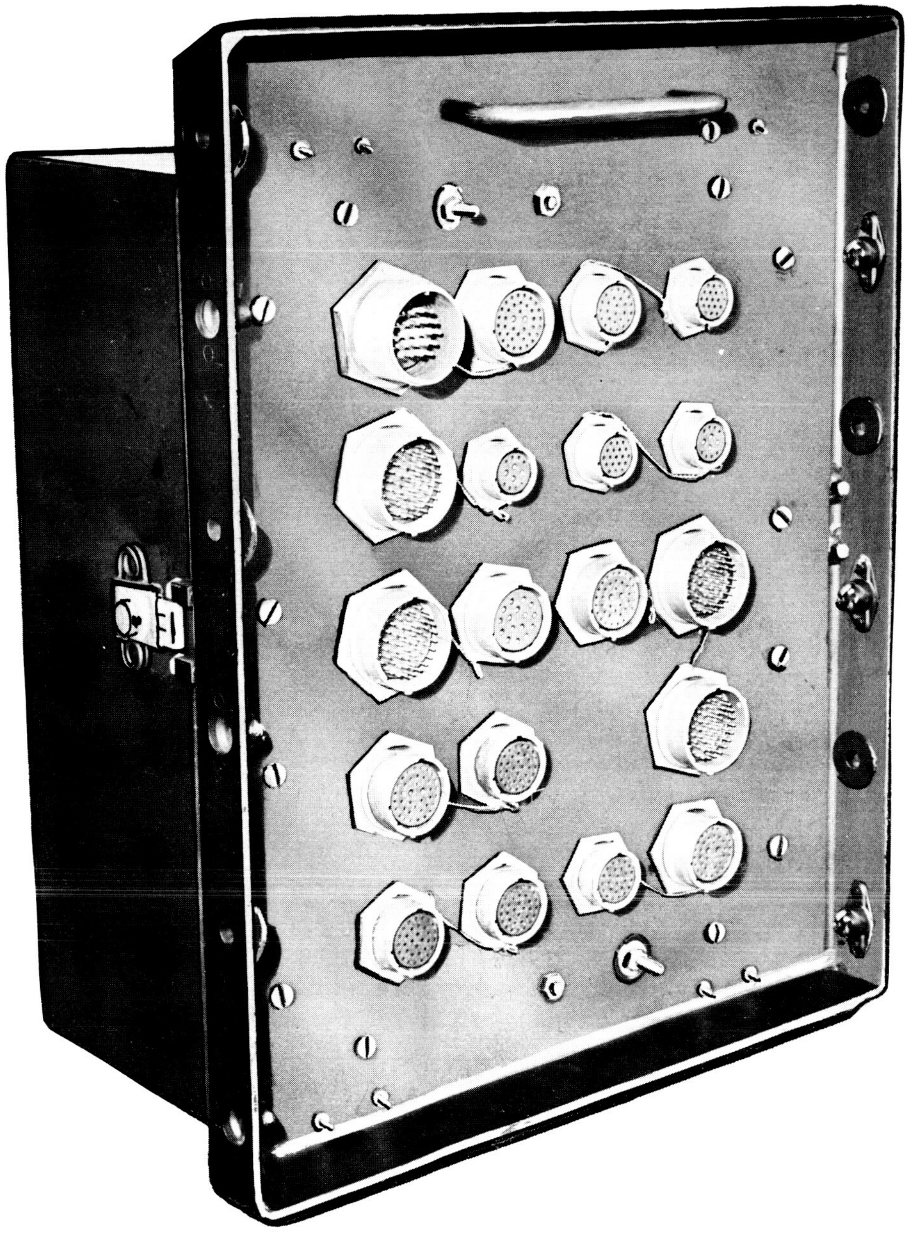


FIGURE 32. PROPULSION DISTRIBUTOR.

Other relays in this distributor are energized when thrust is as prescribed by signals from the thrust O.K. pressure switches. Deenergization of these relays, at low thrust, results in engine cutoff. There are also relays that operate fuel and lox fill-drain and replenishing valves.

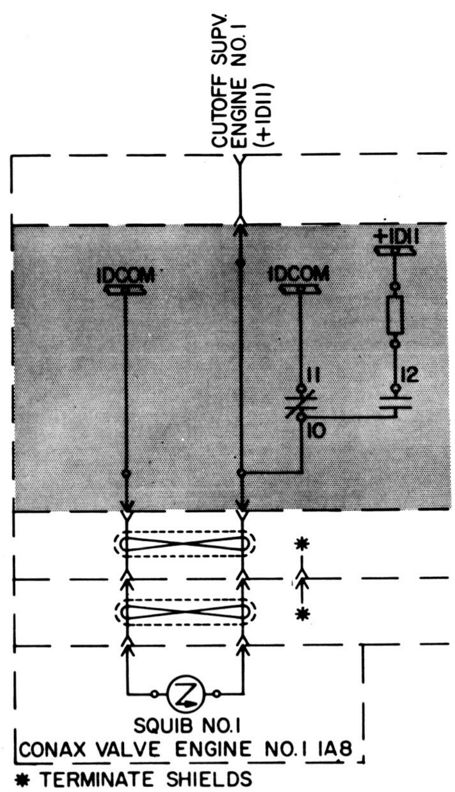


FIGURE 33. CIRCUIT THROUGH PROPULSION DISTRIBUTOR.

The diagram in FIGURE 33 shows the circuitry in the propulsion distributor used for operating the conax valve for one of the engines. After receiving the proper cutoff signal, relay K11 energizes to fire squib number one, operating the engine conax valve to cut off an engine.

4. Control Distributor (FIG. 34)

The control distributor, located in the Instrument Unit, serves as the junction and power distribution point for the circuits associated with vehicle control. The dimensions of this unit are approximately 36 cm by 31 cm by 19 cm, including the 19 connectors and other external hardware. It weighs 10.2 kg.

This distributor contains busses that receive 28-volt power from the power distributor and transmits this power to control the functions as required by the program device, flight sequencer, control computer, and the pressurization system. The control distributor receives signals from the flight sequencer and transmits these signals through relays to

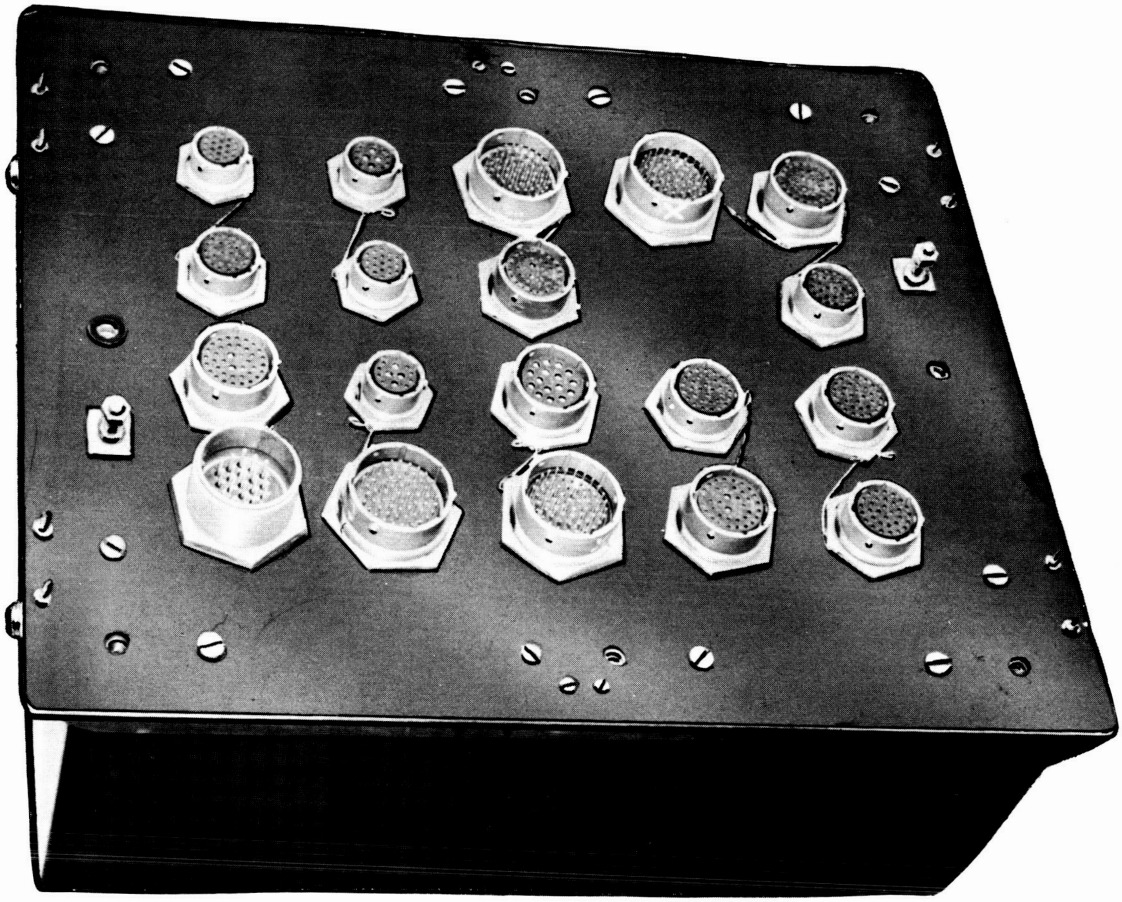


FIGURE 34. CONTROL DISTRIBUTOR (EXTERNAL).

the various vehicle circuits. Three-phase, 115 V, 400 Hz a.c. power from the inverter is routed through the control distributor to a power supply. The power supply converts this power to 60 V d.c. and feeds it to the control distributor for distribution to the angle of attack meters, control computer, and actuators. Three-phase, 115 V, 400 Hz a.c. power is also distributed directly through the control distributor to the stabilized platform, servo amplifiers, and guidance repeater. All of these components are thus integrated into the vehicle circuitry to accomplish vehicle control.

The circuit in FIGURE 35 shows an example of the input and output circuits for the 60 V d.c. power supply and how this power is fed through the control distributor to the control computer.

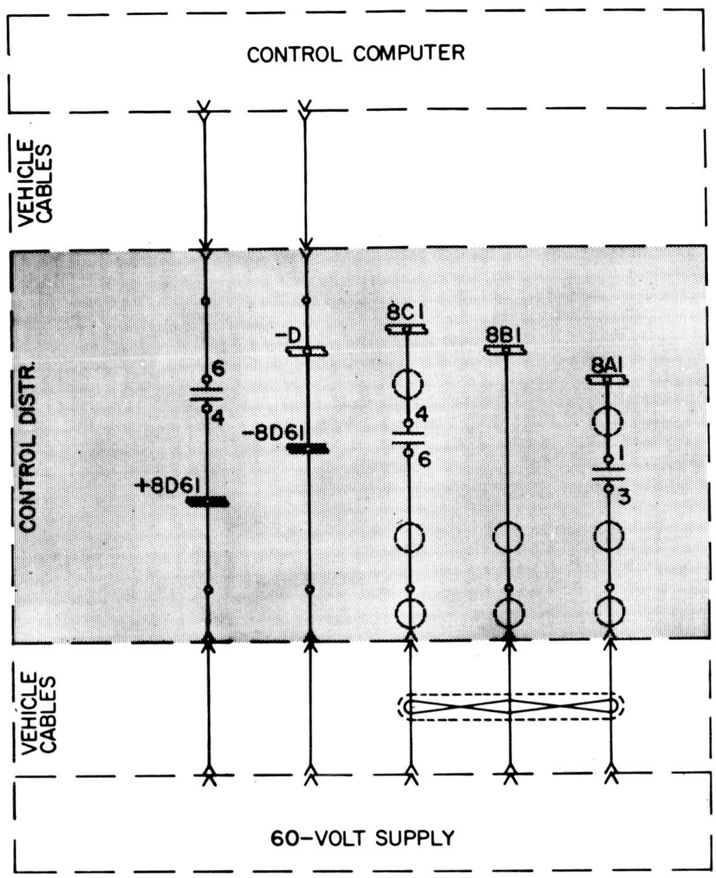


FIGURE 35. CIRCUIT THROUGH CONTROL DISTRIBUTOR.

5. Emergency Detection Distributor (FIG. 36)

The emergency detection distributor is located in the Instrument Unit. The primary purpose of this distributor is to furnish a centralized point for all signals that are to be transmitted to the Apollo payload. FIGURE 37 shows a typical circuit through the emergency detection distributor.

The emergency detection distributors flown on SA-6 and SA-7 are experimental models. The distributors will be flown with two rate gyros (3 axes) which are located in the unpressurized portion of the Instrument Unit.

The emergency detection distributor is approximately 36 cm by 31 cm by 19 cm and weighs 10.2 kg.

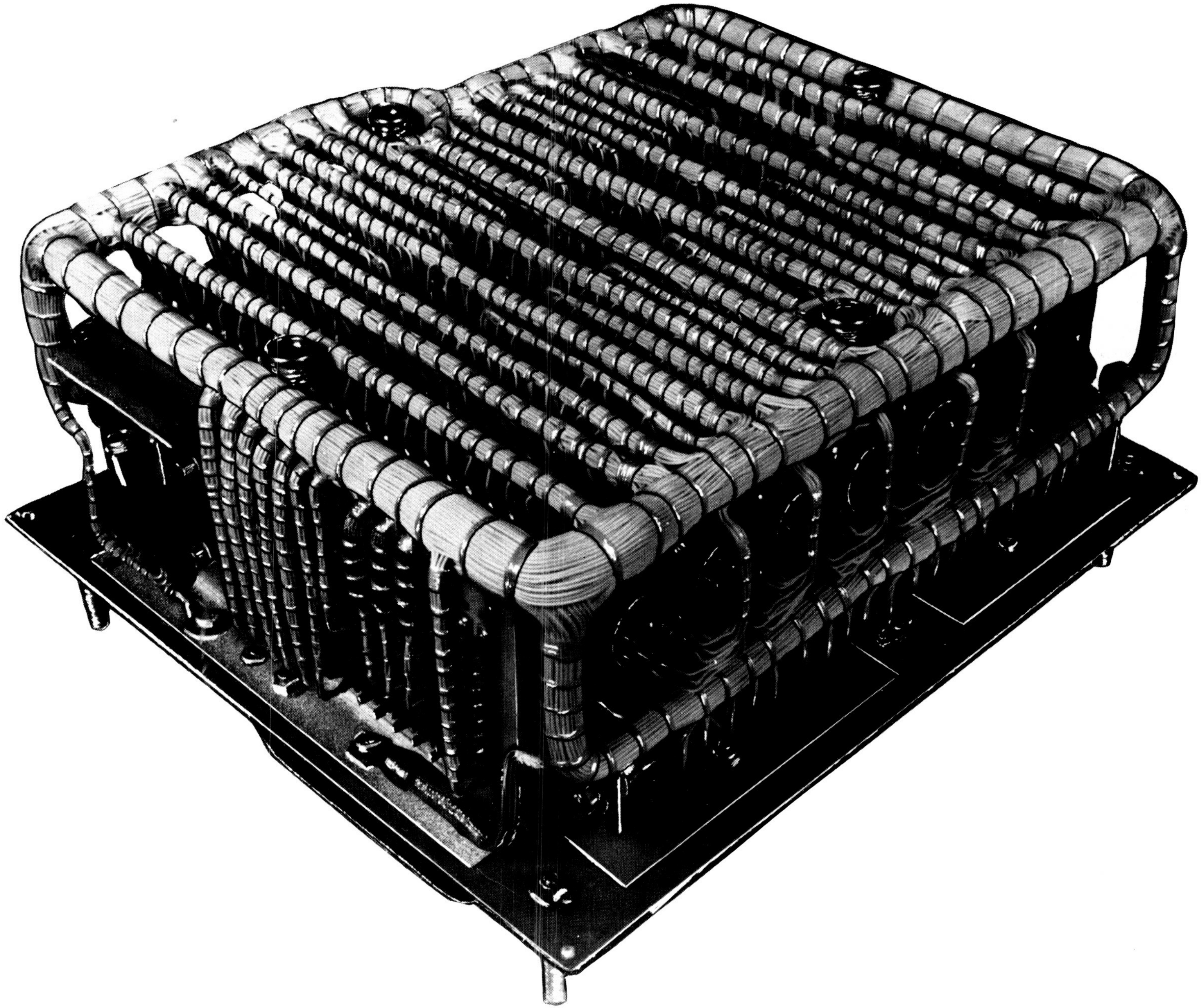


FIGURE 36. EMERGENCY DETECTION DISTRIBUTOR.

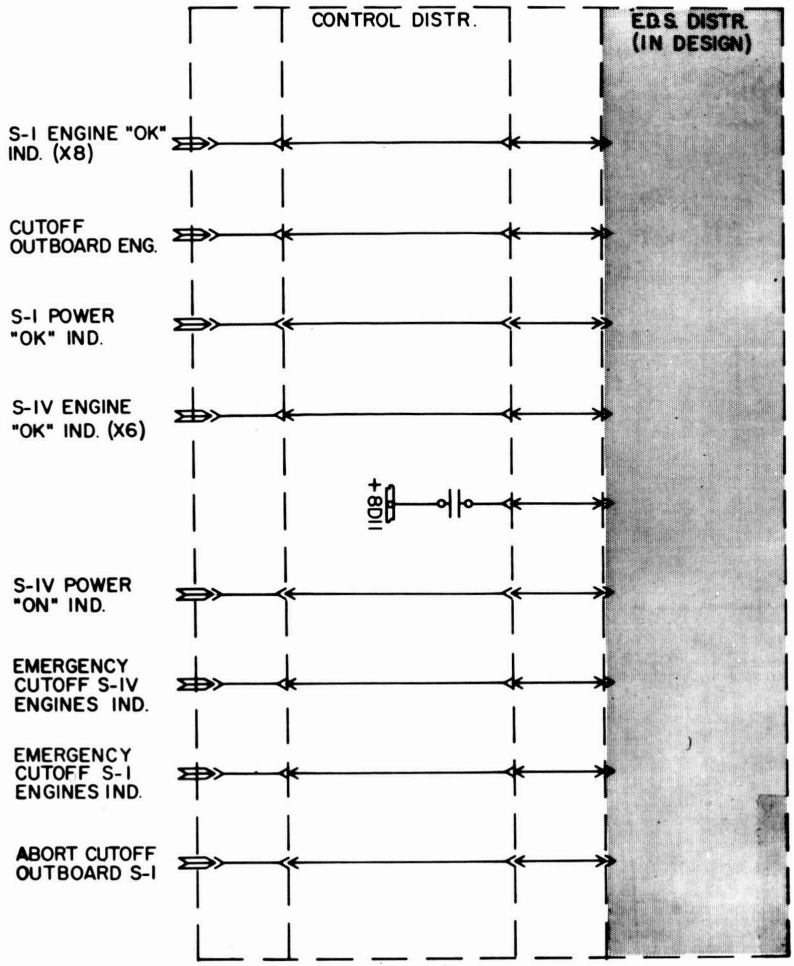


FIGURE 37. CIRCUIT THROUGH EMERGENCY DETECTION DISTRIBUTOR.

6. Main Distributor (FIG. 38)

The main distributor, located in the S-I stage, is physically and mechanically identical to the control distributor located in the Instrument Unit. FIGURE 39 shows a typical circuit through the main distributor.

E. PLUG "J" BOXES (FIG. 40)

Plug distributors, designated as plug type "J" boxes, are used in various units of the vehicle systems to provide convenient and simple junction points for certain vehicle circuits. These "J" boxes also furnish locations for mounting small components that would otherwise occupy needed space in the distributors.

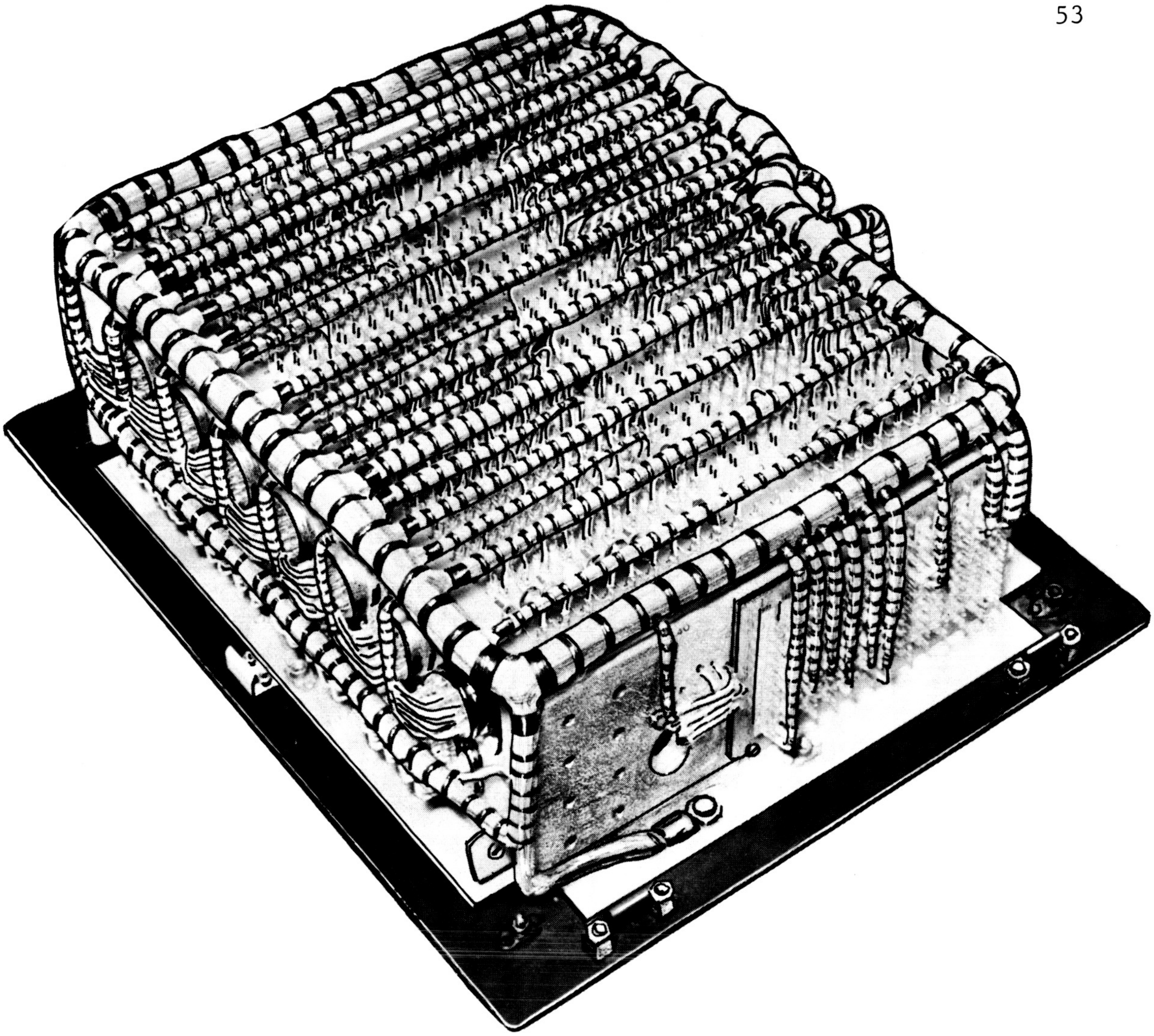


FIGURE 38. MAIN DISTRIBUTOR.

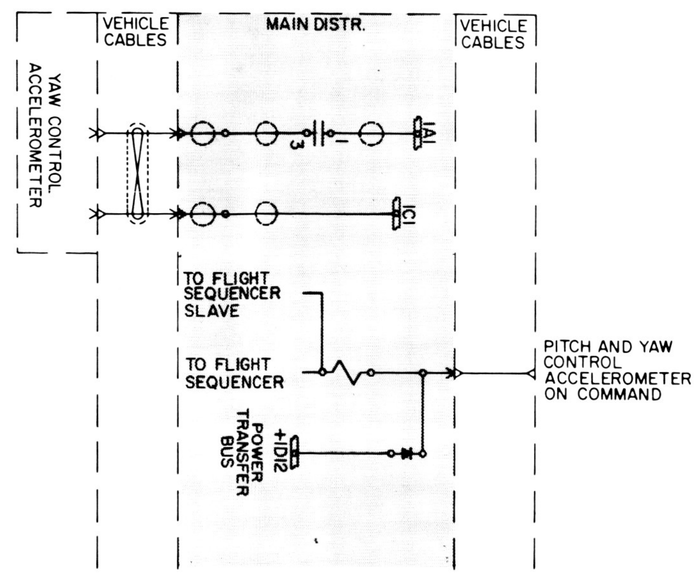


FIGURE 39. CIRCUIT THROUGH MAIN DISTRIBUTOR.

FIGURE 40. PLUG "J" BOXES.

Twenty plug "J" boxes are used in the S-I stage of the block II vehicle; they are designed in two different sizes, according to their use in the circuitry. One "J" box is 7.6 cm by 7.6 cm by 5.1 cm; the other is 7.6 cm by 7.6 cm by 7.6 cm.

Basically, the "J" box is a standard plug with a number of the outer terminals soldered together to form busses. Other pins are connected to either relays or resistors.

From the output terminals of the "J" box, voltage is supplied to vehicle components such as pressure gauges and valves. The pressure gauges use 5-volt power and the valves use 28-volt power.

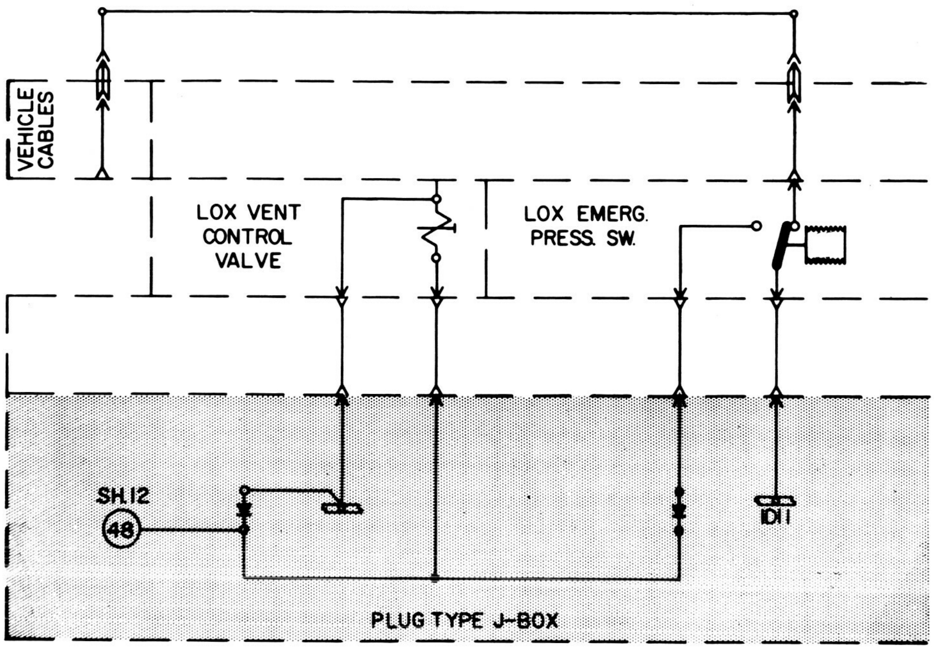


FIGURE 41. CIRCUIT THROUGH PLUG "J" BOX.

FIGURE 41 is a typical circuit of the pressure measurements and shows how measuring voltage is supplied from a plug type "J" box to a pressure pickup.

F. COMMAND DESTRUCT SYSTEM (FIG. 42)

The primary function of the command destruct system is to give emergency thrust termination and fuel dispersion on ground command during flight. Two completely separate systems are used on the SA-5 through SA-7 vehicles; one is located in the S-I stage and one is located in the S-IV stage.

Each system is made up of two identical but independent subsystems. The power is supplied from different sources. The power connection is made directly to the battery side of the main contactor with separate

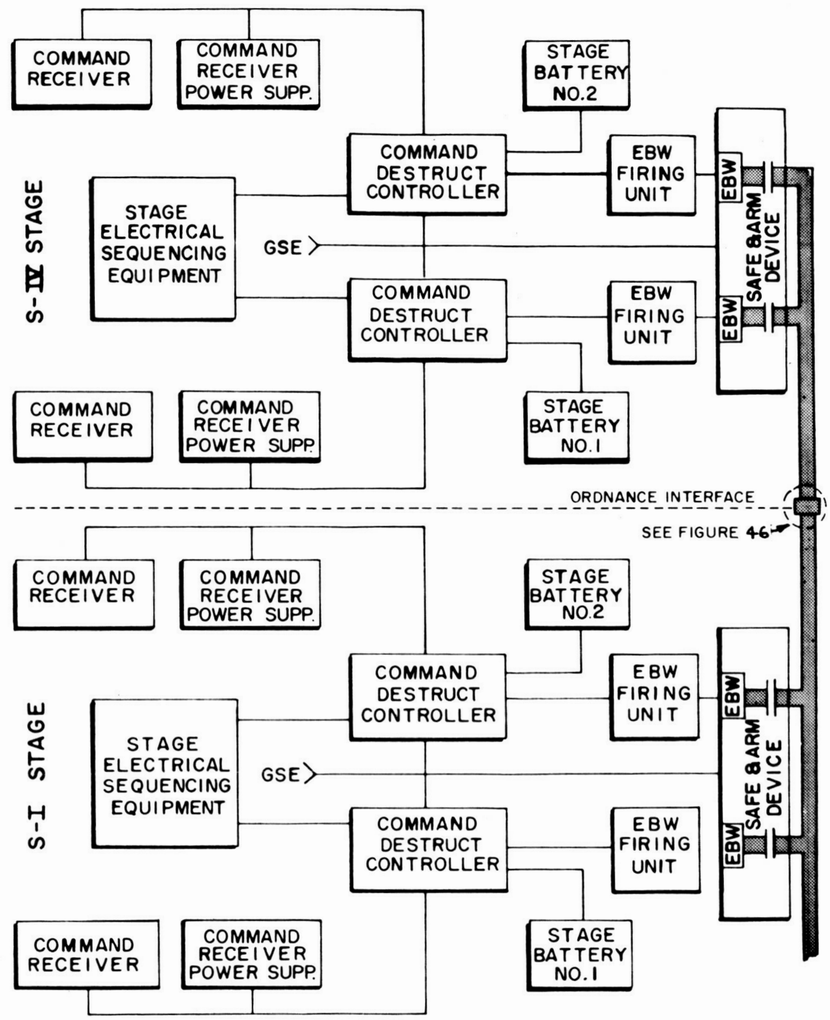


FIGURE 42. BLOCK DIAGRAM OF COMMAND DESTRUCT SYSTEM.

lines provided for the power supply and the EBW firing units. All power lines are also connected to ground power sources with magnetic latching relays transferring the power from external to interna sources.

1. Destruct System Controller (FIG. 43)

The destruct system controller is the central point of the system. It contains all the necessary circuitry to control one set of equipment required for destruction of the Saturn vehicle. Four command

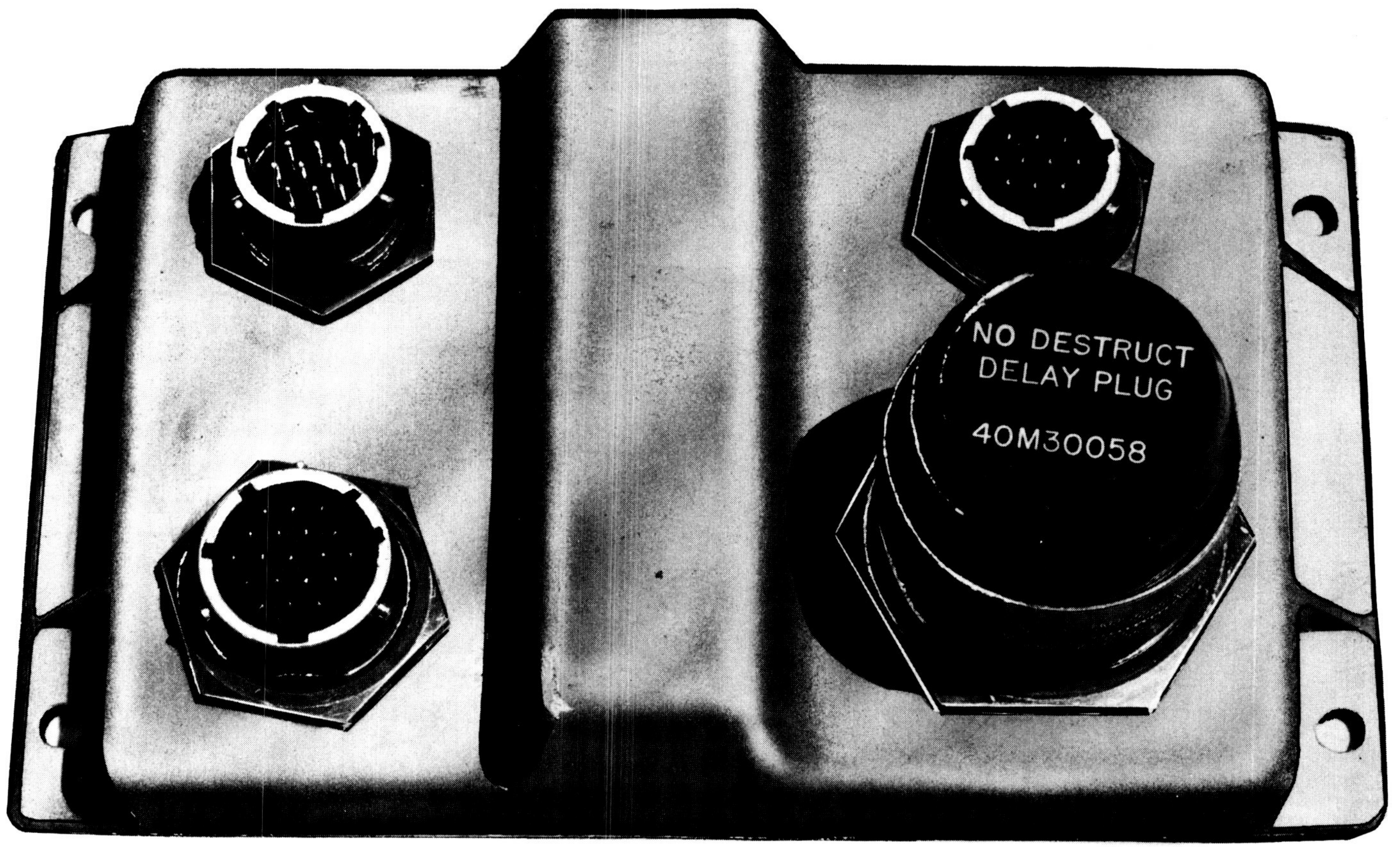


FIGURE 43. DESTRUCT SYSTEM CONTROLLER.

destruct controllers are used on each of the Saturn block II vehicles. Two are used with the S-IV stage command destruct system, and two are used with the S-I stage command destruct system. Each controls a command destruct receiver, an EBW firing unit, and necessary signals to the vehicle system for thrust termination. This controller has been designed in such a way that it is capable of being adapted to either manned or unmanned, orbital or nonorbital flights.

There are six relays and four connectors in each controller. Connector J2 is utilized for the replaceable module (no destruct delay plug) which selects the mode of operation (FIG. 43); i. e., either no delay between arming command and destruct command, or a time delay between arming command and destruct command, or a time delay between the two commands, or preparing circuitry to enable the command receiver or the firing unit to be turned off during flight. FIGURE 44 shows an example of a circuit through the destruct system controller.

The destruct system controller weighs 0.107 kg and measures 12.2 cm by 8.6 cm by 2.5 cm.

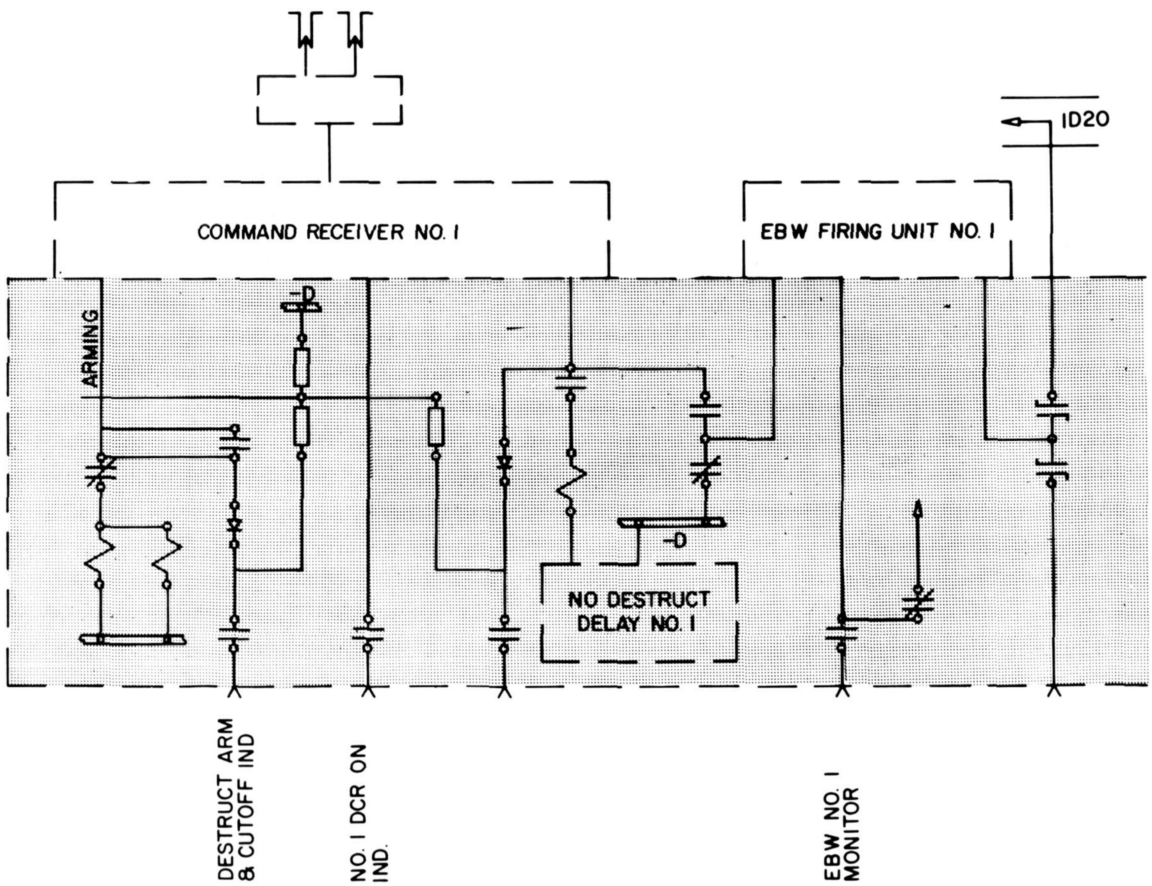


FIGURE 44. CIRCUIT THROUGH DESTRUCT SYSTEM CONTROLLER.

2. Exploding Bridgewire Firing Unit (FIG. 45)

The exploding bridgewire unit is used to ignite the exploding bridgewire. A transistorized oscillator and transformer network in the unit steps up the 28-volt input voltage to a high voltage output. This high voltage output is used to charge a 1 μF capacitor to 2300 volts. A signal from the command receiver through the destruct controller causes a gap tube in the exploding bridge firing unit to arc. The gap tube arcing discharges the condenser to ignite the exploding bridgewire.

Each of the exploding bridgewire firing units is connected to a detonator which is tied to primacord through common safe and arm units. The primary function of the safe and arm units is to give a visual and mechanically-controlled means of providing safety for personnel during installation of exploding bridgewire detonators and primacord in its safe position. The arming or disarming of the unit can be made by mechanical means at the vehicle or electrically from the ground any time prior to the liftoff. Electrical activation of the unit is accomplished by a rotary solenoid. The supervision of the safe and armed positions is accomplished by microswitches built into the unit with indications brought to ground support equipment.

Arming of the unit for the flight must be made prior to liftoff. Armed indication on the ground is required for proceeding with countdown.

Thirty exploding bridgewire units will be flown on each of the SA-5 through SA-7 vehicles. Table 1 lists the number of units and their functions on both the S-I and the S-IV stage. Each exploding bridgewire unit is approximately 16 cm by 8 cm by 8 cm; each weighs approximately 2 kg.

The stage interconnection of explosives for the destruct system is shown in FIGURE 46.

TABLE 3. EXPLODING BRIDGEWIRE UNITS TO BE USED ON BLOCK II VEHICLES.

S-I STAGE		S-IV STAGE	
FUNCTION	NO. UNITS	FUNCTION	NO. UNITS
Retro Rocket Ignition	8	Ullage Rocket Ignition	8
Destruct	2	Ullage Rocket Jettison	2
		Stage Separation	2
		Vent Ports	2
		Retro Rocket Ignition	4
		Destruct	2

FIGURE 45. **EXPLODING** BRIDGEWIRE FIRING UNIT.

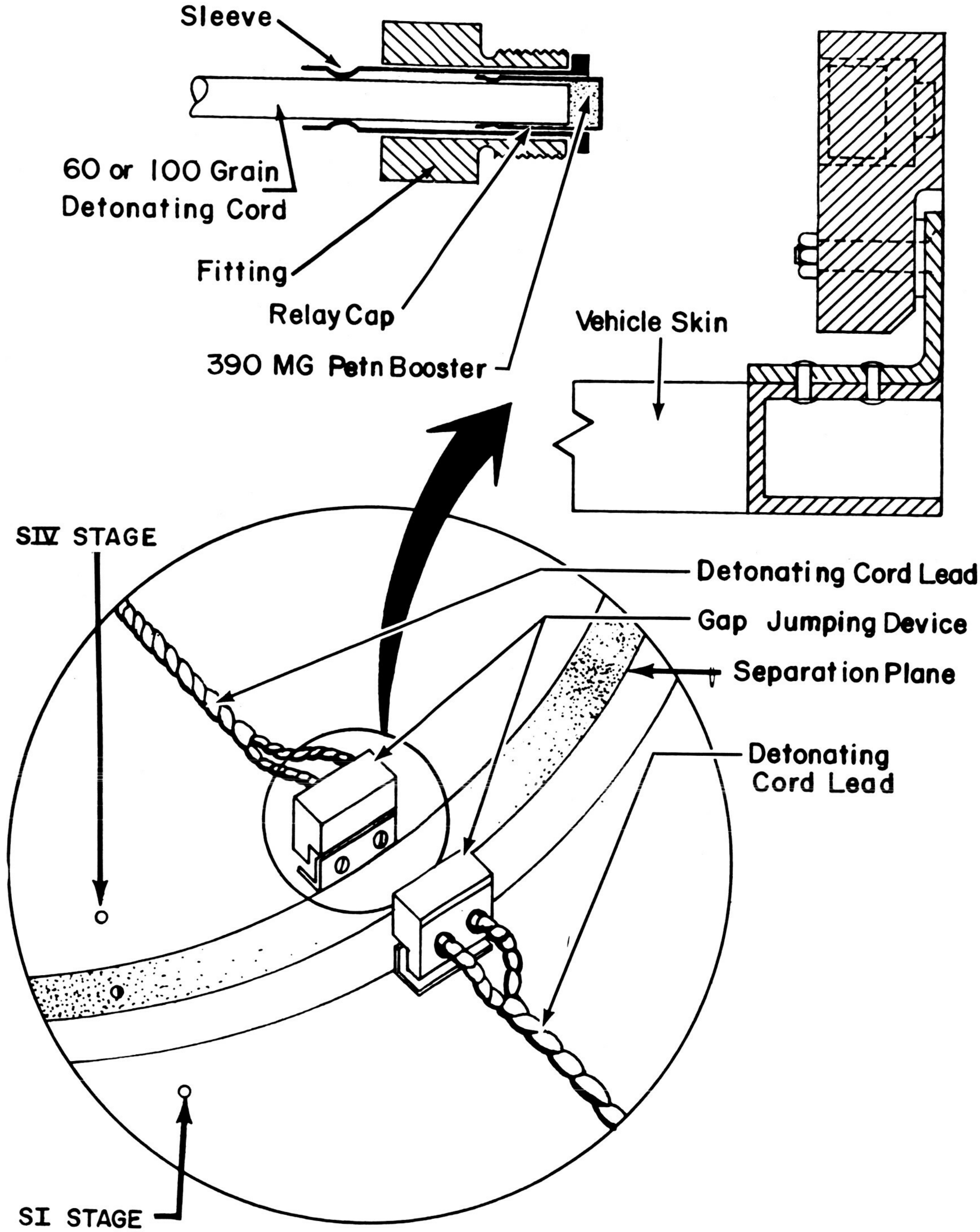


FIGURE 46. STAGE INTERCONNECTION OF EXPLOSIVES FOR THE DESTRUCT SYSTEM.

G. SWITCH ASSEMBLIES (FIG. 47)

Four switch assembly devices are in each of the SA-5 through SA-7 vehicles. Two are located in unit 12 of the S-I stage, and two are mounted in the Instrument Unit.

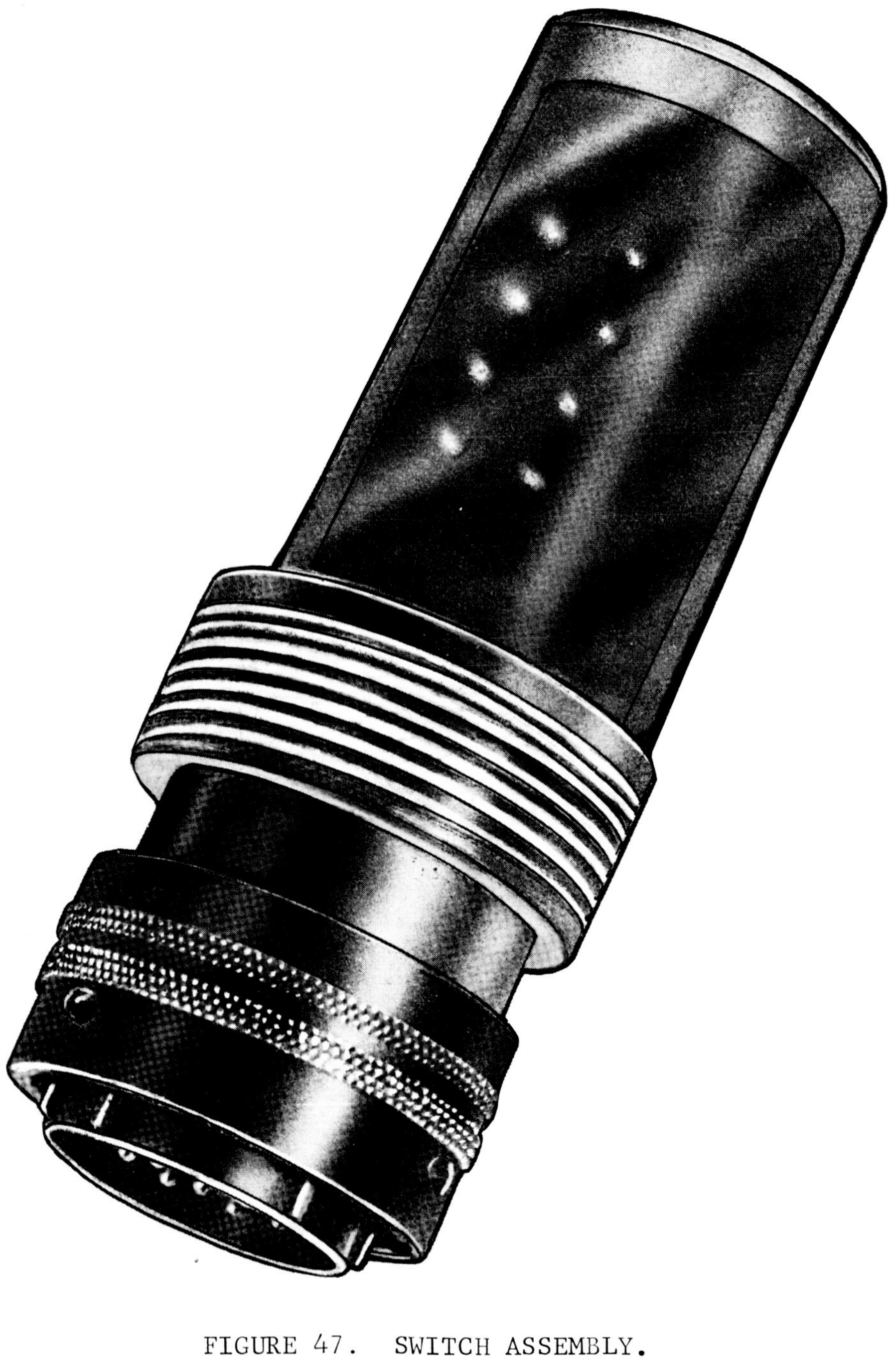


FIGURE 47. SWITCH ASSEMBLY.

A switch assembly is cylindrical in shape, measures 10.4 cm in length by 3.8 cm in diameter, and weighs 0.12 kg. Two of these units are plugged into connector jacks on each of the power distributors (12A25 in the S-I stage and 802A2 in the Instrument Unit).

FIGURE 48 shows the switch assembly to consist of one connector with a squib and jumper wires soldered to terminals in the backshell. The squib switch actuates at liftoff to establish, with its one-shot contacts, circuits which parallel critical circuits through contacts in the power distributors.

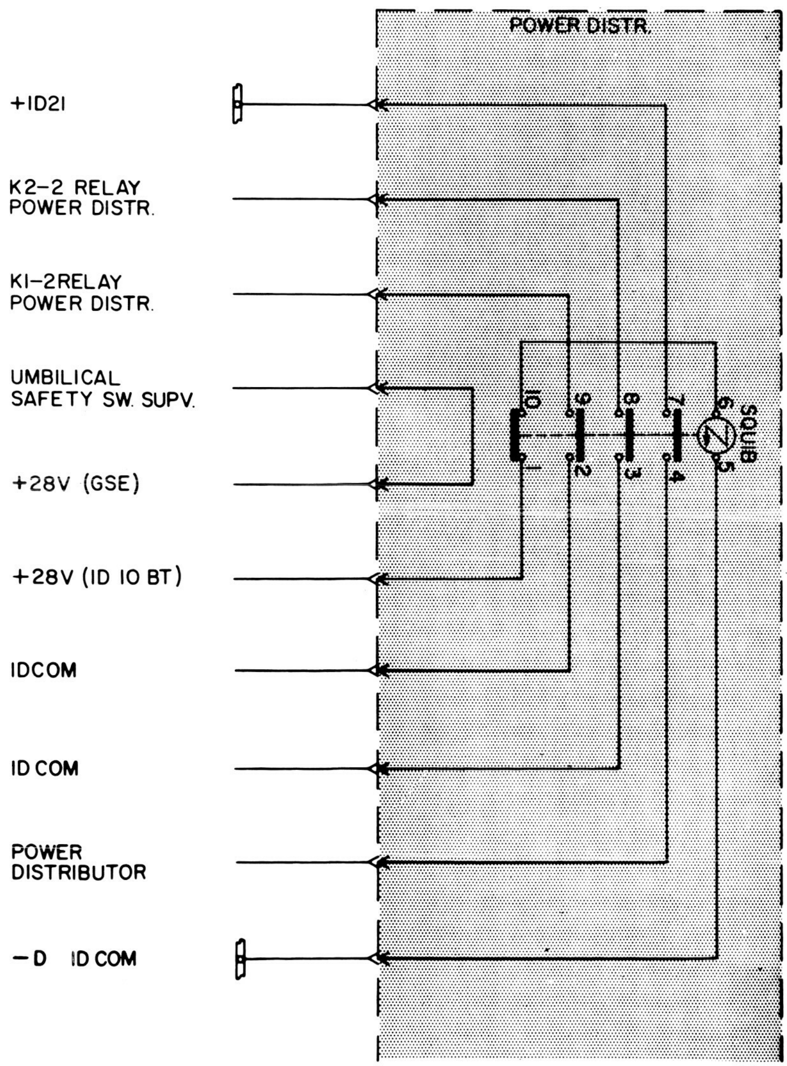


FIGURE 48. CIRCUIT THROUGH SWITCH ASSEMBLY.

H. TWENTY-FIVE SECOND DELAY TIMER (FIG. 49)

This delay-timing device, located in unit 12 of the S-I stage, is approximately 6 cm by 11 cm by 3 cm and weighs 0.2 kg. It starts operation at the time of separation of the S-I and S-IV stages; 26 seconds later, it gives a signal to the eight camera recovery pods. This signal actuates solenoids that cause the pods to be pneumatically ejected from the S-I stage as it falls away. The camera recovery pods are later picked up from the sea.

The timer is triggered by a signal from the S-I stage flight sequencer slave. It closes an internal relay after the delay time has elapsed, supplying 28 volts to the solenoids. The circuitry is simply a conventional resistor-capacitor timing circuit.

This device also operates a tape recorder, which has been running during flight of the S-I stage. The timer starts the play-back from the tape recorder, which transmits data through the telemetry system to the ground.

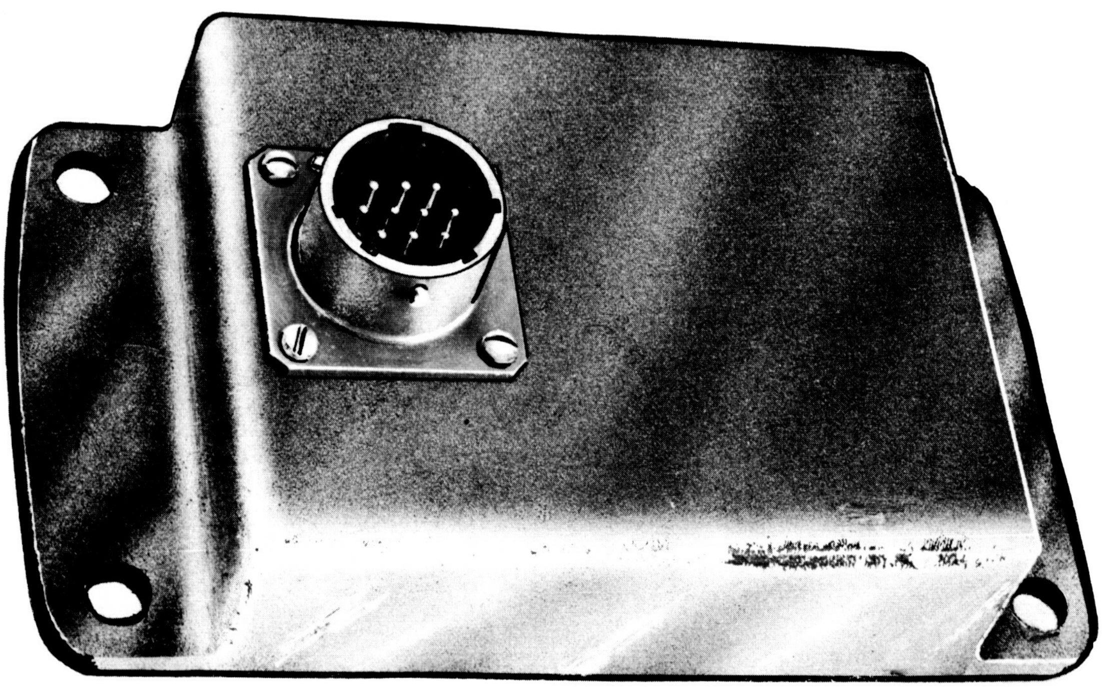


FIGURE 49. 25-SECOND DELAY TIMER.

I. ELECTRICAL INTERFACES

The electrical interface of the S-I/S-IV stages consists of four 55-pin connectors and four 8-pin connectors. The electrical interface of the S-IV/Instrument Unit consists of five 55-pin connectors. FIGURE 50 illustrates a typical interface connection used for this purpose.

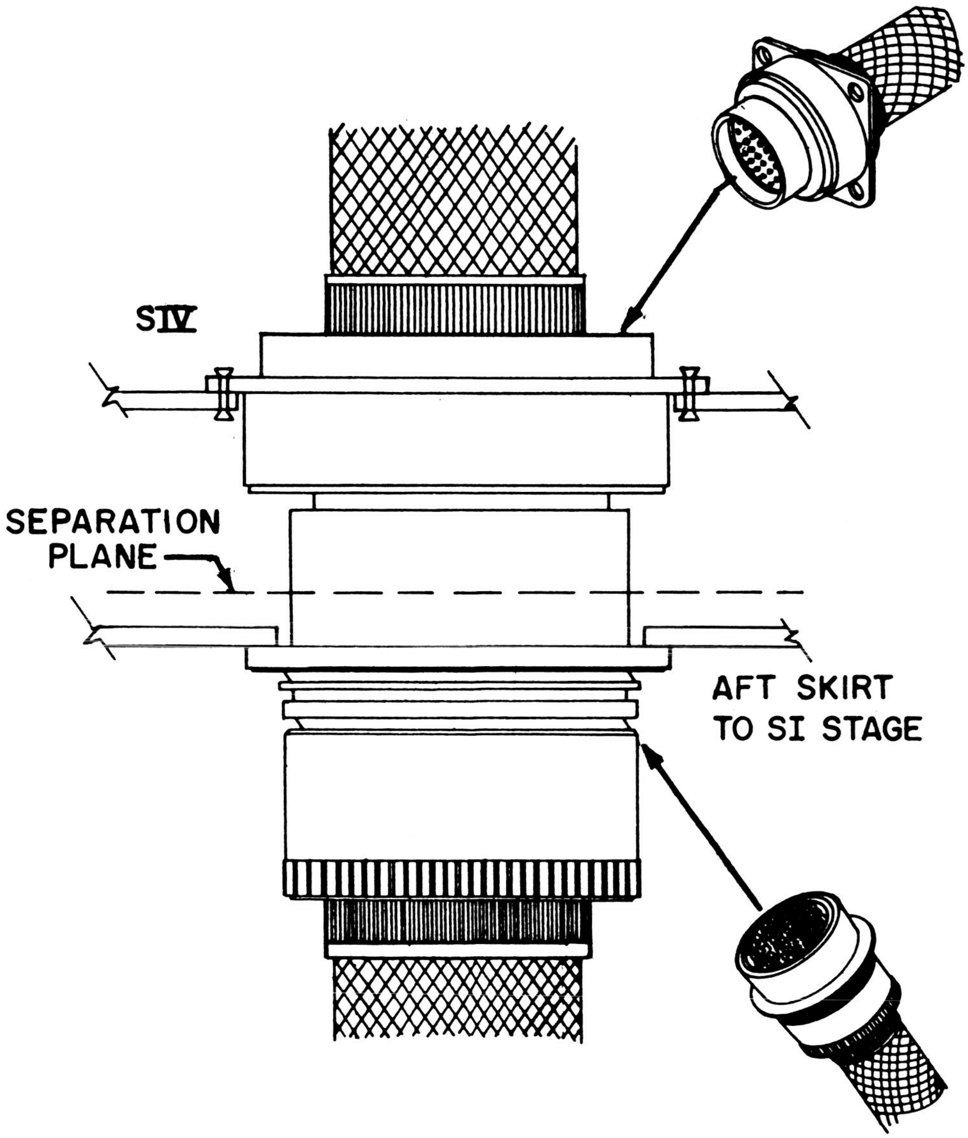


FIGURE 50. TYPICAL EXAMPLE OF INTERFACE CONNECTOR.

To save wire and reduce complexity, certain lines in the control system that utilize the same function in both the S-I and S-IV stages are switched in the S-IV stage by a flight control switch. This is accomplished by applying a voltage to the motor of the flight control switch at S-I separation, thereby interrupting any signal to the S-I stage from the control computer in the Instrument Unit and applying the signal to the S-IV stage.

The method to be utilized in transmitting signals between stages is shown in FIGURE 51.

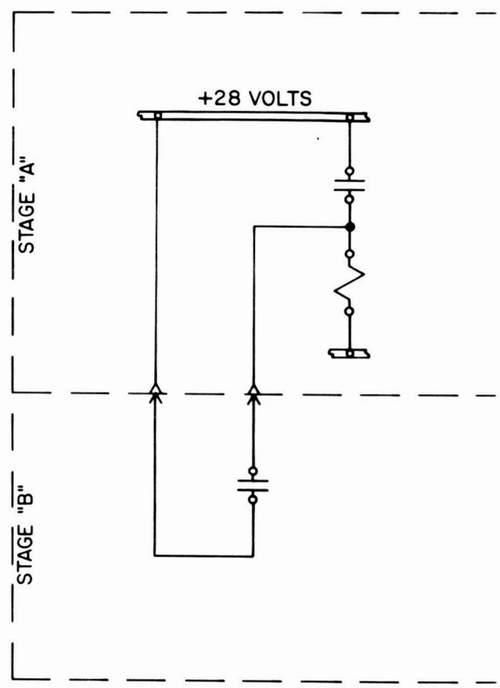


FIGURE 51. METHOD UTILIZED IN TRANSMITTING SIGNALS BETWEEN STAGES.

If stage "A" requires a signal from stage "B," it will furnish stage "B" with +28 volts; stage "B" will in turn switch the +28 volts and return the switched signal to stage "A." The +28 volts for signal transmission need only be furnished one time for a set of signals between stages. This method of transmitting signals allows the d.c. power of each stage to be completely independent and also eliminates the problems of current transfer in the negative side of the d.c. power supply.

APPROVAL MTP-ASTR-E-63-5

SATURN I ELECTRICAL POWER AND SYSTEMS INTEGRATION
SA-5 THROUGH SA-7

By

A. A. Conway and H. K. Bennett

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R. G. SMITH
Chief, Airborne Systems Integration Section

R. J. Boehme

R. J. BOEHME
Chief, Components and Power Supply Section

Phil Youngblood

for H. J. FICHTNER
Chief, Electrical Systems Integration Branch

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